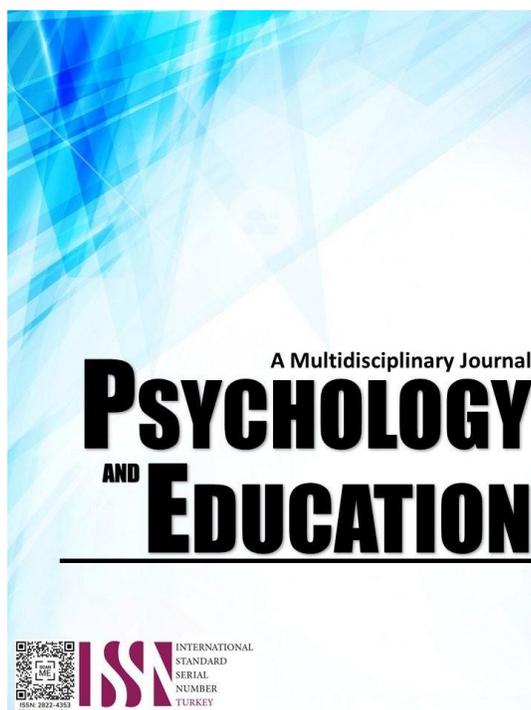


**A PATH ANALYSIS OF FACTORS SHAPING SCIENTIFIC ATTITUDES:
INQUIRY-BASED LEARNING ENVIRONMENT, METACOGNITIVE
AWARENESS, AND CRITICAL THINKING IN
SCIENCE EDUCATION**



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A Path Analysis of Factors Shaping Scientific Attitudes: Inquiry-Based Learning Environment, Metacognitive Awareness, and Critical Thinking in Science Education

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Abstract

This study investigates the direct and indirect effects of inquiry-based learning environment, metacognitive awareness, and critical thinking on the scientific attitudes of first-year college students enrolled in three colleges of Davao de Oro. Using a descriptive correlational design with path analysis, the study examined the interconnectedness of these variables. The results indicate that an inquiry-based learning environment, metacognitive awareness, and critical thinking significantly predict students' scientific attitudes. Notably, the best-fit model shows that metacognitive awareness exerts a substantial influence on inquiry-based learning environment, metacognitive awareness, and critical thinking, emphasizing its foundational role in shaping these factors. While metacognitive awareness and an inquiry-based learning environment have a modest effect on scientific attitudes, critical thinking has a comparatively greater impact. Overall, the model effectively captures the relationships among these variables, reflecting a coherent, well-fitting structure. These findings imply that cultivating metacognitive awareness, promoting an inquiry-based learning environment, and strengthening critical thinking can synergistically enhance students' scientific attitudes, ultimately supporting deeper engagement and more effective science learning.

Keywords: *inquiry-based learning environment, metacognitive awareness, critical thinking, scientific attitudes, path analysis, science education*

Introduction

Scientific attitudes are important qualities that students must acquire to develop their 21st-century skills (Kusuma et al., 2021). Developing scientific attitudes is crucial in maintaining students' consistent focus and interest in learning science (Shanderi & Suwardi, 2023). The main goal of science education is to foster students' positive attitudes and increase their interest in learning science (Mao et al., 2021). However, students' diminishing ability to solve problems using scientific processes, lack of skills in evaluating scientific information logically, and low willingness to learn scientific concepts, leading to a poor scientific attitude, have had a significant impact on the educational paradigm and even on the broader community (Fathayati et al., 2021). Hence, this study investigates the interrelationships among the inquiry-based learning environment, metacognitive awareness, and critical thinking in shaping students' scientific attitudes in science education.

Moreover, problems with scientific attitudes have emerged globally. According to the joint report of the International Association for the Evaluation of Educational Achievement and the United Nations Educational, Scientific and Cultural Organization (2020), only 38% of secondary level students around the world demonstrated high level of proficiency in learning science; however, their scientific attitudes have not progressed over the years, resulting to their declining skills in scientific investigation as well as their confidence in scientific methods to solve problems. In addition to that, the World Bank (2022) strongly emphasizes that 57% of the students in the low and middle-income countries have not fully developed their scientific attitudes, hindering further improvement on their ability to think critically and rationally and to apply their scientific reasoning skills in real-world contexts, ultimately impacting the quality of science education worldwide.

In support of that, many global educational institutions have also experienced the same issues. For instance, in the Moroccan school context, Boukayoua et al. (2021) found that 70% of students lacked critical thinking, making it difficult for them to understand scientific concepts. Moreover, in one university in Indonesia, about 60% of students showed a lack of confidence in the scientific method and poor observational skills, leading to low engagement with scientific materials and affecting their academic performance in science (Mihardi et al., 2020). Furthermore, in China, many students have developed poor scientific attitudes, such as disinterest and low confidence in learning science, creating barriers to their learning (Mao et al., 2021). At one university in Oklahoma, about 60% of college students report decreased curiosity about scientific information and processes in learning science, which affects their motivation to explore scientific concepts (Reed et al., 2022).

Meanwhile, in the Philippines, Capiral (2022) indicated that only 40% of junior high school students showed confidence in using scientific processes to solve problems and to logically evaluate scientific information, leaving many students struggling to understand scientific concepts. Similarly, Babaylo (2023) found that 40% of students at a public school in Cadiz City demonstrated a lack of willingness to use scientific methods to solve problems and evaluate scientific knowledge, leading to poor academic performance and engagement.

Furthermore, Lantajo (2022) found that students at one university in Leyte often lack curiosity and critical thinking when analyzing scientific information to draw rational conclusions, resulting in lower academic performance and declining participation in science-related activities. Another study conducted at a university in Quezon City found that only 36% of students generally lacked confidence

and curiosity about learning science, leading to poor engagement and lower academic outcomes (Adarlo et al., 2022). Based on the data, many Filipino learners across different levels have experienced difficulties in developing their scientific attitudes, including a lack of critical thinking when evaluating scientific information and a lack of willingness and confidence to use scientific methods to solve problems. Consequently, these problems in their scientific attitudes can hinder the development of their scientific skills and compromise the quality of science education, particularly at the national level.

Locally, in Davao De Oro, a study by Naquila and Israel (2022) found that 53.5% of students lack confidence in scientific methods, hindering their development of scientific attitudes. Moreover, Rebuscas and Dales (2022) reported that grade 9 learners enrolled in a particular public school in Davao De Oro lacked critical thinking and observational skills in learning scientific concepts and methods, resulting in poor engagement and academic performance in science. The problems concerning students' underdeveloped scientific attitudes towards learning science extend beyond secondary education. In the three identified colleges in Davao de Oro, similar challenges have been observed, with students' lack of scientific attitudes leading to declining interest and motivation in learning science. Hence, this issue is pervasive and persists across different educational levels.

Although many studies have investigated students' scientific attitudes (Boukayoua et al., 2020; Mihardi et al., 2020), these works were conducted in an international setting. Moreover, studies were conducted in national contexts (Naquila & Israel, 2022; Rebuscas, 2022), but these involve different variables. Furthermore, the researcher had not yet encountered studies that explore the collective impact of an inquiry-based learning environment, metacognitive awareness, and critical thinking on students' scientific attitudes in learning science. Additionally, this study aims to establish such a connection with first-year college students enrolled in three colleges in Davao de Oro.

In light of the above studies, poor scientific attitudes towards learning science remain a widespread issue across international, national, and local contexts, and persist across different stages and learning areas of education. Likewise, this alarming problem can significantly impede students' ability to develop scientific attitudes and skills, which are crucial not only for academic success but also for future endeavors. Without an immediate resolution to this problem, it may develop into a broader educational issue and weaken scientific literacy in the country in the near future.

Hence, this study aims to explore the direct and indirect influences of inquiry-based learning environments, metacognitive awareness, and critical thinking on students' scientific attitudes towards learning science. In the same manner, this study can also provide support for enhancing educational practices and support mechanisms for science education at the higher education level in both local and national contexts.

Additionally, the outcomes of this study enable teachers to refine their teaching methodologies, fostering students' scientific attitudes and leading to improved learning outcomes in science. Nevertheless, students also benefit from this study's outcomes, as it will help them recognize the importance of developing scientific attitudes to succeed in learning science.

Research Questions

The purpose of this study was to examine, through path analysis, the direct and indirect relationships among inquiry-based learning environments, metacognitive awareness, and critical thinking, and how these interconnected variables influence the scientific attitudes of first-year college students in science education across the three colleges of Davao de Oro. In particular, the study aimed to address the following questions:

1. What is the extent of scientific attitudes of students in terms of:
 - 1.1. rationality;
 - 1.2. open-mindedness;
 - 1.3. confidence in scientific method;
 - 1.4. curiosity; and
 - 1.5. aversion to superstition?
2. What is the extent of inquiry-based learning environment in terms of:
 - 2.1. student participation;
 - 2.2. paying attention to ideas;
 - 2.3. collaboration;
 - 2.4. learning;
 - 2.5. asking questions;
 - 2.6. observation; and
 - 2.7. focusing on problems?
3. What is the extent of metacognitive awareness of students in terms of:
 - 3.1. declarative knowledge;
 - 3.2. procedural knowledge;
 - 3.3. conditional knowledge;
 - 3.4. planning;

- 3.5. monitoring; and
- 3.6. evaluation?
4. What is the extent of critical thinking of students in terms of:
 - 4.1. remembering;
 - 4.2. understanding;
 - 4.3. analyzing;
 - 4.4. applying;
 - 4.5. evaluating; and
 - 4.6. creating?
5. Is there a significant relationship between:
 - 5.1. inquiry-based learning environment and scientific attitudes of students;
 - 5.2. metacognitive awareness and scientific attitudes of students;
 - 5.3. critical thinking and scientific attitude of students;
 - 5.4. inquiry-based learning environment and critical thinking of students;
 - 5.5. metacognitive awareness and critical thinking of students; and
 - 5.6. inquiry-based learning environment and metacognitive awareness of students?
6. Do inquiry-based learning environment, metacognitive awareness and critical thinking predict scientific attitude of students?
7. Do the hypothesized models fit the data?

Methodology

Research Design

This study employed a quantitative research design, incorporating both descriptive and correlational approaches alongside path analysis. Quantitative research design typically involves the use of surveys to gather data, which are then analyzed to generate generalizable findings (Chali et al., 2022). Similarly, this design is suitable for examining the relationships among variables within a study (Van Deursen, 2020).

Additionally, a descriptive research approach was also employed. This approach is beneficial when the researcher intends to describe a situation or phenomenon without manipulating the variables (Aggarwal & Ranganathan, 2019). Beyond identifying patterns or characteristics within the data, this approach provides valuable insights that can inform understanding and further research (Siedlecki, 2020). The descriptive approach is well-suited for this study, as it allows the researcher to systematically document and summarize the levels and distribution of inquiry-based learning, metacognitive awareness, critical thinking, and scientific attitudes among first-year college students from the three institutions in Davao de Oro.

Moreover, the researcher used a correlational approach to investigate the relationships among the study's variables systematically. This approach is particularly appropriate for examining the strength and direction of associations between variables (Lawrence, 2023). This study enabled a rigorous assessment of the extent to which inquiry-based learning, metacognitive awareness, critical thinking, and scientific attitudes are related among first-year college students.

Respondents

The respondents of this study are the first-year college students enrolled in the three higher education institutions in Davao de Oro during the 2024–2025 academic year. To ensure an adequate, statistically representative sample, the researcher used the Raosoft sample size calculator. From a total population of 1,429 first-year students across the three institutions, a sample of 539 respondents was determined at a 95% confidence level, ensuring sufficient precision for the study's quantitative analyses.

The respondents from the three institutions in Davao de Oro were proportionately distributed: 280 from School A, 161 from School B, and 98 from School C. Stratified random sampling was employed to ensure that specific subgroups within the population were adequately represented. This technique involves dividing the population into distinct strata based on shared characteristics and then randomly selecting participants from each stratum (Hankin & Newman, 2019). The researcher employed this sampling method to enhance the representativeness of the sample, ensure that each respondent had an equal probability of selection, and reinforce the overall validity of the study.

Instrument

The researcher employed survey questionnaires adapted from published journals for data collection. Prior to administration, the instruments were pilot-tested with 30 students who were not part of the study sample to ensure content validity. Additionally, the reliability of the instruments was assessed using Cronbach's alpha to determine the internal consistency of the items in each questionnaire.

Inquiry-Based Learning Environment Scale. This instrument was utilized to evaluate the extent of the inquiry-based learning environment. The researcher employed a survey questionnaire adapted from Siaroglan (2021). The instrument consists of 31 items,

divided into seven indicators: student participation, which includes seven items; attention to ideas, consisting of six items; collaboration, comprising seven items; learning, with five items; asking questions, containing two items; observations, including two items; and problem-focused engagement, with two items. Prior to implementation, the questionnaire underwent a pilot test, yielding a Cronbach's alpha of 0.995, indicating excellent internal consistency.

Metacognitive Awareness Instrument. This survey questionnaire was designed to measure students' metacognitive awareness and was adapted from the work of Tak et al. (2022). It consists of 30 items organized into five indicators: declarative knowledge (5 items), procedural knowledge (4 items), conditional knowledge (5 items), planning (5 items), and monitoring (6 items). The pilot test of the questionnaire yielded a Cronbach's alpha of 0.987, indicating excellent internal consistency.

Critical Thinking Questionnaire. This instrument was employed to assess students' critical thinking and was adapted from the work of Kobylarek et al. (2022). The questionnaire consists of 25 items organized into six indicators: evaluating (4 items), creating (6 items), applying (4 items), remembering (3 items), analyzing (4 items), and understanding (4 items).

Scientific Attitude Scale. This instrument was employed to measure the extent of students' scientific attitude. The survey questionnaire was adapted from Khan and Siddiqui (2020). It comprised 38 items organized into five indicators: rationality (7 items), open-mindedness (10 items), confidence in the scientific method (9 items), curiosity (6 items), and aversion to superstition (6 items). The pilot testing of the instrument yielded a Cronbach's alpha of 0.988, indicating excellent internal consistency.

Procedure

The procedures outlined below represent the systematic steps the researcher followed to ensure the proper conduct of the study and the successful collection of data. The researcher first secured permission to conduct the study, followed by the random selection of respondents. This was followed by general orientation and obtaining informed consent and a data privacy notice, the administration of survey questionnaires, and, finally, the checking, collation, and processing of data.

Seeking permission to conduct the study. A primary step in the study involved seeking permission from the appropriate authorities. The researcher submitted a letter to the Research Ethics Committee for review and approval. Once the study received committee approval, the researcher obtained a letter of endorsement from the dean. After obtaining the signed approval, the researcher submitted formal letters to the college presidents of the three institutions where the study was conducted.

Random selection of respondents. Following the approval of all necessary letters, respondents were randomly selected. Assistance from enumerators, who were staff members of the three campuses, was sought to identify potential respondents. Enumerators provided only respondents' names and contact information. Using the master list, the researcher employed the RAND function in Microsoft Excel to assign random numbers to each name, then used the sort and filter tools to select the final sample.

The researcher then sent formal invitations to the selected respondents via email or messenger, requesting their consent to participate in the study. Upon receiving approval, the researcher scheduled an orientation at a time and location convenient for the respondents, during which the study's objectives and methodology were explained. Respondents were informed about confidentiality measures and were asked to sign a confidentiality agreement prior to participation.

General orientation and seeking of informed consent. Before administering the survey questionnaires, the researcher conducted an orientation and obtained informed consent and a data privacy notice from respondents. During orientation, the study's purpose, confidentiality measures, and the voluntary nature of participation were clearly communicated.

Respondents were provided with a data privacy notice detailing the collection, storage, and use of their personal data, the legal basis for processing, their rights under the Data Privacy Act of 2012, and the researcher's and regulatory bodies' contact information. Respondents were given ample time to ask questions before signing the forms.

To document the process and ensure ethical compliance, the orientation was recorded with photographs and audio. Respondents were allowed to maintain anonymity by using face masks, caps, or other means, and were encouraged to wear comfortable clothing. Orientation locations were chosen to minimize noise and distractions, and respondents were allowed to select a convenient and private setting.

Administration and Retrieval of Questionnaire. After validation and approval of the survey instruments and securing all necessary letters, the questionnaires were distributed to the selected respondents with the assistance of enumerators. Health protocols were observed throughout the process, and respondents were allowed to choose a comfortable location to complete the survey.

Enumerators were informed of the study's purpose, procedures, and guidelines before administering the questionnaires. Respondents were given 10 to 20 minutes to complete the surveys, and data collection lasted 1 week to ensure adequate participation.

Supplementary sessions were offered to those unable to attend the orientation. Completed questionnaires were securely collected in sealed envelopes by the enumerators and subsequently retrieved by the researcher. Enumerators and respondents received tokens of appreciation for their assistance and participation, and all procedures adhered to the Data Privacy Act of 2012.

Data Checking, Collating, and Processing. The researcher ensured that all collected questionnaires were securely stored and accounted

for. Data were checked for completeness and accuracy, and any inconsistencies or missing information were addressed. Verified responses were organized into a structured format for ease of analysis, and tabulated data were entered into a spreadsheet while maintaining confidentiality.

The tabulated data were then analyzed using appropriate statistical tools to identify patterns, trends, and insights. The findings were interpreted in relation to the study objectives, and their implications were discussed in connection with existing knowledge and potential future research or practice.

Collected data were disclosed to the Research Ethics Committee for verification, with respondents informed in advance of this process. Respondents were also provided with contact information for the regulatory bodies to address any questions or concerns about their personal information. All data were securely stored for a maximum of three years and permanently deleted afterward to prevent unauthorized disclosure, in compliance with the Data Privacy Act of 2012.

Data Analysis

The researcher used the data processing tools listed below to thoroughly analyze the collected data. Specifically, the researcher used the mean, standard deviation, Pearson's *r* correlation, multiple linear regression, and path analysis.

Mean. This statistical tool was used to determine the average level of the collected data. This measure allowed the researcher to assess the general levels of the inquiry-based learning environment, metacognitive awareness, critical thinking, and scientific attitudes across their respective indicators. By analyzing the overall means, the researcher gained a clearer understanding of the data's overall trends, while appropriate inferential statistical analyses were employed to examine relationships among the variables.

Standard Deviation. This statistical tool was used to measure the extent of dispersion of students' responses from the central value. It provided a clearer picture of how consistently or variably students perceived the inquiry-based learning environment, as well as their metacognitive awareness, critical thinking, and scientific attitudes.

Pearson *r* Correlation. This statistical tool was employed to determine the strength and direction of the relationships between continuous variables. It enabled the researcher to assess the degree of association between each exogenous variable, namely, the inquiry-based learning environment, metacognitive awareness, and critical thinking, and the endogenous variable, scientific attitudes.

Multiple Linear Regression Analysis. This statistical tool is used to examine the predictive relationships between a single dependent variable and multiple independent variables. This study allowed the researcher to assess the extent and significance of the influence of the exogenous variables, namely, the inquiry-based learning environment, metacognitive awareness, and critical thinking, on the endogenous variable, scientific attitudes.

Path Analysis. This statistical tool was used to examine the detailed relationships among the variables and to analyze the causal pathways through which the inquiry-based learning environment, metacognitive awareness, and critical thinking influence scientific attitudes. This tool allowed the researcher to quantify the strength and significance of both direct and indirect effects between the exogenous and endogenous variables.

Ethical Considerations

Smith (2024) highlighted that safeguarding participants' welfare, privacy, and ethical concerns forms the foundation of research ethics, enhancing the reliability, transparency, and credibility of the collected data while minimizing bias. The study emphasized social value, informed consent, participants' vulnerability, risks, benefits, safety, privacy and confidentiality, justice, transparency, researcher qualifications, adequacy of facilities, and community involvement, with each component carefully considered to ensure the ethical and successful execution of the research.

Social Value. This component ensures that a study contributes to the public good and justifies the resources and participation it requires (Rodriguez Duque et al., 2024). This study aimed to enhance the scientific attitudes of first-year students across three college institutions in Davao de Oro. It examined how inquiry-based learning environments, metacognitive awareness, and critical thinking influence students' scientific attitudes during science learning. The findings of this study have the potential to improve decision-making, problem-solving, and academic performance, and to enable students to contribute positively to their communities and society. Beyond enhancing scientific attitudes, the study fostered an environment that further develops inquiry skills, metacognitive awareness, and critical thinking, cultivating scientifically literate and capable individuals.

Informed Consent. Informed consent ensures that participants are fully aware of the purpose of the study, potential risks and benefits, and their rights before deciding to participate (Grant, 2021). The researcher secured informed consent from all respondents to uphold ethical standards. Participants were explicitly informed that their involvement was voluntary and that they could withdraw at any time without consequence. The researcher also guaranteed confidentiality of personal information and responses, fostering trust and encouraging honest participation.

Vulnerability of Research Participants. This component addresses the increased risk of harm, exploitation, or inadequate protection faced by specific individuals or groups due to personal, situational, or contextual factors (Gordon, 2020). Although all respondents

were of legal age, the researcher recognized potential vulnerabilities, such as membership in the LGBTQ+ community, pregnancy, nursing, or physical disabilities. Measures were implemented to protect privacy and inclusivity, including allowing participants to conceal their identities with face masks or other materials, wear comfortable clothing, select convenient locations, and participate in a private, secure environment. The researcher remained attentive to participant concerns throughout the study, ensuring their safety and respect.

Risks, Benefits, and Safety. This component safeguards participants by minimizing potential harm, while promoting positive outcomes (White, 2020). The study posed minimal risk, primarily the potential discomfort of answering survey questions. Voluntary participation was emphasized, and respondents could skip questions or withdraw at any time without penalties. Benefits included increased self-awareness, improved academic performance, and insights for educators to enhance teaching strategies that foster inquiry-based learning, metacognitive awareness, critical thinking, and scientific attitudes.

Privacy and Confidentiality. Protecting participants' personal information is essential to maintain trust and ethical integrity (Bhandari, 2021). The researcher ensured that all personal information and responses were securely stored and not shared outside the scope of the study, except for verification purposes with the Research Ethics Committee. Respondents' identities were anonymized, with the option to use pseudonyms, and contact information was provided to address any concerns, fostering open and honest participation.

Justice. Justice ensures fairness and equity throughout the research process, including the equitable selection of participants and fair distribution of benefits and burdens (Pratt et al., 2020). Respondents were selected through stratified random sampling from the three institutions, ensuring all eligible students had a fair opportunity to participate. Tokens of appreciation were provided to acknowledge participants' time and effort. The researcher maintained respect, inclusivity, and engagement with all respondents throughout the study.

Transparency. Transparency entails open sharing of research procedures, data collection, analysis, and interpretation to ensure accountability, reproducibility, and credibility (Moravcsik, 2019). All data were carefully documented and shared with participants. The researcher reported findings honestly, avoiding bias, and provided contact information for queries, reinforcing trust and study credibility.

Qualification of the Researcher. A researcher's knowledge, skills, and ethical awareness are critical to ensuring credibility and integrity, particularly in handling ethical issues (Mirza et al., 2023). The researcher holds a Bachelor of Secondary Education major in Science and is currently pursuing a Master of Arts in Education, major in Teaching Science. With three years of teaching experience and participation in various professional development programs, the researcher possesses practical insights into educational methodologies and student engagement. Guided by an experienced adviser, the researcher ensured proper execution of research procedures and ethical compliance, demonstrating competence in conducting this study.

Adequacy of Facilities. This component emphasizes the importance of providing safe and suitable resources and environments for ethical research conduct (Cacciattolo, 2015). The researcher selected study locations within the three institutions that met safety standards, including proper ventilation, lighting, seating, and minimal distractions. Institutional approvals were obtained, and resources, including materials, rooms, and expert guidance, were secured to ensure a conducive research environment.

Community Involvement. Meaningful community involvement requires consideration of local needs and collaborative engagement, ensuring social relevance and impact (Fregonese, 2018). This study engaged all first-year students across three institutions, creating a supportive environment that reinforced inquiry-based learning, metacognitive awareness, and critical thinking. Faculty, administrators, and students actively participated through discussions and workshops, fostering shared responsibility and promoting the sustainable enhancement of science education in the community.

Results and Discussion

This section presents the discussion of the study's results on the intercollective impact of an inquiry-based learning environment, metacognitive awareness, and critical thinking on the scientific attitudes of first-year college students from the selected three colleges in Davao de Oro. This includes all responses from respondents gathered through validated survey questionnaires during data collection, which were analyzed with expert help. This section checks the tabulated data, their descriptive interpretations, and the answers to the hypotheses tested in this study.

Extent of Students' Scientific Attitudes in terms of Rationality

Table 1 presents the extent of students' scientific attitudes regarding rationality. The item "Science is suitable for all students regardless of gender" recorded the highest mean of 4.28 with a standard deviation of 0.76. This was followed by "Studying science subjects enhances our intellect," which obtained a mean of 4.26 with a standard deviation of 0.75, and "Scientific careers are more useful to the advancements in society," which garnered a mean of 4.25 with a standard deviation of 0.76.

These findings indicate that students strongly affirm the inclusivity of science, its role in developing intellectual abilities, and its importance in societal progress. On the other hand, the item "Scientists do not live normal family lives" had the lowest mean of 3.82 and a standard deviation of 0.95, suggesting that although some students perceive this notion as accurate, it is less strongly endorsed than the other items related to rationality.



Table 1. *The Extent of Scientific Attitudes of Students in terms of Rationality*

Items	Mean	SD	Descriptive Equivalent
1. Traditional society hampers the growth of science.	4.13	0.78	Often
2. Science is suitable for all students regardless of gender.	4.28	0.76	Always
3. Scientific careers are more useful to the advancements in the society.	4.25	0.76	Always
4. Studying science is not everybody's cup of tea.	4.08	0.82	Often
5. Traditional beliefs should be accepted even when they are against scientific research.	4.14	0.78	Often
6. Studying science subjects enhances our intellect.	4.26	0.75	Always
7. Scientists do not live normal family lives.	3.82	0.95	Often
Category Mean	4.14	0.80	Often

The overall category mean of 4.14 and standard deviation of 0.80 indicate that students generally demonstrated a high level of rationality in their scientific attitudes. The descriptive rating of “Often” reflects that students consistently value facts, evidence, and logical reasoning over personal biases or emotions. Furthermore, the moderate spread of responses shows relative consistency among the group, suggesting that rational thinking is a well-established component of their scientific attitudes. The results confirm Nikolaev's (2021) findings, which emphasize that rational students develop logical thinking abilities that enable them to analyze and evaluate information scientifically. Similarly, Schmidt (2024) highlighted that students with a well-developed rational mindset are better able to solve scientific problems using systematic methods, thereby advancing the critical scientific attitudes essential for investigation and exploration. Overall, the present study's findings demonstrate that students with a high level of rational thinking cultivate strong inquiry skills, skepticism, and persistent reasoning, which, in turn, foster more robust scientific attitudes.

Extent of Students' Scientific Attitudes in terms of Open-mindedness

Table 2 illustrates the extent of students' open-mindedness. The item “Study of science helps in thinking of new ideas” had the highest mean of 4.27 and a standard deviation of 0.76, indicating that students consistently perceive science as a source of creativity and innovation. Closely related, the item “Positive criticism is useful for advancement of knowledge” received a mean of 4.18 with a standard deviation of 0.83. At the same time, “Science subjects have infinite opportunities” followed with a mean of 4.14 and a standard deviation of 0.83.

Table 2. *The Extent of Scientific Attitudes of Students in terms of Open-mindedness*

Items	Mean	SD	Descriptive Equivalent
1. Science makes us dependent on machines.	3.91	0.90	Often
2. Sharing too much knowledge with others is harmful.	3.76	1.07	Often
3. Any new thing can be criticized in the absence of facts.	4.02	0.85	Often
4. Science subjects have infinite opportunities.	4.14	0.83	Often
5. Science is not responsible for low moral standards.	3.89	0.91	Often
6. Positive criticism is useful for advancement of knowledge.	4.18	0.83	Often
7. Opinion of novice (new/unexperienced person) should not be accepted immediately even though it is supported by evidence.	3.83	0.99	Often
8. Scientific advancements have also adverse effects on humanity.	4.09	0.80	Often
9. Study of science helps in thinking new ideas.	4.27	0.76	Always
10. One may feel offended by a person who has different thinking from him/her.	4.07	0.86	Often
Category Mean	4.02	0.88	Often

These results underscore that students view science as a discipline that encourages novel thinking, values constructive critique, and provides boundless opportunities for exploration. In contrast, the item “Sharing too much knowledge with others is harmful” registered the lowest mean of 3.76 with a standard deviation of 1.07. This suggests that such a belief is less consistently supported by respondents and is perceived as more variable than the other indicators of open-mindedness. Taken together, the overall category mean of 4.02 and standard deviation of 0.88 indicate that students generally exhibit a high level of open-mindedness in their scientific attitudes. The descriptive rating often signifies that they are inclined to accept and evaluate ideas based on evidence, even when the outcomes differ from their prior assumptions or personal beliefs. Moreover, the relatively moderate variability in responses suggests that students share the view that open-mindedness is integral to scientific learning, particularly by embracing diverse perspectives, welcoming constructive feedback, and adjusting viewpoints in light of credible evidence.

The findings resonate with Błaszczak (2022), who emphasized that students who demonstrate open-mindedness in assessing scientific information are better able to make sound decisions through careful, critical consideration. Similarly, Hassan et al. (2020) found that open-minded students maintain objectivity even when confronted with new scientific evidence, enabling them to adapt their perspectives in light of credible data. These results suggest that the development of open-mindedness fosters curiosity, innovation, and continuous learning qualities that strengthen scientific attitudes.

Extent of Students' Confidence in Scientific Method

Table 3 shows the extent of students' scientific attitudes, specifically their confidence in the scientific method. The item “One should



be honest and truthful in collecting and recording data” had the highest mean of 4.40 and a standard deviation of 0.72, indicating that students strongly value honesty and accuracy in scientific work.

Table 3. *The Extent of Scientific Attitudes of Students in terms of Confidence in Scientific Method*

Items	Mean	SD	Descriptive Equivalent
1. Enough evidences should be collected before accepting an idea.	4.28	0.76	Always
2. Testing of knowledge should be procedural.	4.32	0.74	Always
3. One should be honest and truthful in collecting and recording data.	4.40	0.74	Always
4. Data can be manipulated according to the need.	4.01	0.94	Often
5. One should suspend (delay) his/her decision in the absence of sufficient data.	4.07	0.81	Often
6. Known is the basis to know the unknown.	4.12	0.79	Often
7. Questioning attitude helps in defining a problem.	4.17	0.76	Often
8. Any hypothesis should be accepted or rejected based on sufficient evidence.	4.12	0.79	Often
9. Knowledge should be considered tentative.	4.29	0.75	Always
Category Mean	4.20	0.79	Always

This was followed by “Testing of knowledge should be procedural,” which received a mean of 4.32 and a standard deviation of 0.75, indicating that students recognize the importance of following clear, systematic steps when testing ideas. In addition, the items “Knowledge should be considered tentative” and “Enough evidence should be collected before accepting an idea” had mean scores of 4.29 and 4.28 with standard deviations of 0.75 and 0.76, respectively, reflecting students’ awareness that scientific knowledge is not absolute and should always be supported by sufficient evidence.

On the other hand, the item “Data can be manipulated according to the need” obtained the lowest mean of 4.01 with a standard deviation of 0.97. Although students generally disagreed with this idea, the higher spread of responses suggests that some students may still hold less strict views about how data should be treated.

Overall, the category mean of 4.20 and standard deviation of 0.82 indicate that students have a high level of confidence in the scientific method. The results suggest that they trust processes such as experimentation, systematic testing, and evidence-based reasoning. The relatively consistent responses also indicate that most students share this positive outlook, which is important for shaping ethical practices and the responsible use of scientific methods.

The results align with the findings of Khan and Siddiqui (2020), who observed that students who systematically search for information or solutions tend to develop greater confidence in scientific processes. In the same way, Tommasi et al. (2021) emphasized that confidence in the scientific method is linked to more positive attitudes toward scientific knowledge, noting that students who remain open to new information and solutions demonstrate stronger trust in scientific practices.

These findings underscore that students’ confidence in the scientific method plays a crucial role in shaping their scientific attitudes, reinforcing their belief in methodical inquiry and evidence-based reasoning. Furthermore, the more students strengthen this confidence, the more capable they become in sharpening their analytical skills, particularly in recognizing misinformation and discerning reliable scientific information.

Extent of Students’ Scientific Attitudes in terms of Curiosity

Table 4 presents the extent of students’ scientific attitudes regarding curiosity. The item “One should explore the unknown” recorded the highest mean of 4.31 with a standard deviation of 0.72, indicating that students strongly value the pursuit of new knowledge. This was followed by “One should be interested to know ‘WHY’ of natural phenomenon” with a mean of 4.25 and a standard deviation of 0.74, and “One should search for reality behind appearances” with a mean of 4.20 and a standard deviation of 0.76.

These results suggest that students consistently recognize the importance of questioning, exploring, and seeking deeper explanations in science. In contrast, the item “To do enquiry is a task of scientists and not of common man” obtained the lowest mean of 3.84 with a standard deviation of 0.93. While this still reflects that curiosity is often expressed, the lower score indicates that some students may perceive scientific inquiry as a specialized task rather than a shared responsibility.

Table 4. *The Extent of Scientific Attitudes of Students in terms of Curiosity*

Items	Mean	SD	Descriptive Equivalent
1. One should explore the unknown.	4.31	0.72	Often
2. There is no conclusion as final or ultimate.	4.02	0.85	Always
3. There is a scientific cause for everything that takes place in this world.	4.10	0.82	Often
4. To do enquiry is a task of scientists and not of common man.	3.84	0.93	Often
5. One should be interested to know “WHY” of natural phenomenon.	4.25	0.74	Always
6. One should search for reality behind appearances.	4.20	0.76	Always
Category Mean	4.12	0.80	Often

Overall, the category mean of 4.12 and standard deviation of 0.80 indicate a high level of curiosity among students. This suggests that learners maintain inquisitive mindsets and are eager to understand underlying scientific principles more deeply. The moderate spread



of responses demonstrates relative consistency across the group, indicating that curiosity is a well-embedded trait in their scientific attitudes.

The results parallel the findings of Putra et al. (2021), who emphasized that students' curiosity is strengthened when integrated with scientific approaches, thereby improving their learning outcomes in science. Likewise, Jirout (2020) explained that learners who nurture curiosity by asking questions during discussions exhibit more advanced scientific thinking. Taken together, these findings highlight curiosity as a vital driving force in the development of scientific attitudes, fostering active engagement, a more profound understanding of scientific concepts, and improved decision-making through inquiry and evidence-based reasoning.

Extent of Students' Scientific Attitudes in terms of Aversion to Superstition

Table 5 presents the extent of students' scientific attitudes regarding superstition. The item "A black cat crossing one's path does not bring bad luck" recorded the highest mean of 4.28 with a standard deviation of 0.80, indicating that students strongly reject this common superstition.

This suggests a significant shift toward rational thinking and a preference for scientific explanations over culturally ingrained but unfounded beliefs. Similarly, items such as "There is nothing like fate; man makes his own fate" and "Use of lemon and green chillies cannot protect us from evil eye" also received high mean scores of 4.13 and 4.12, respectively, both showing standard deviations close to 0.80, further affirming the students' critical stance toward non-scientific claims.

Table 5. *The Extent of Scientific Attitudes of Students in terms of Aversion to Superstition*

Items	Mean	SD	Descriptive Equivalent
1. Scientist should report his/her discovery even if it is contradictory to religion.	4.14	0.76	Often
2. Use of lemon and green chillies cannot protect us from evil eye.	4.12	0.80	Often
3. For the solution of a problem, one should not go to an astrologer.	4.08	0.85	Often
4. There is nothing like fate; man makes his own fate.	4.13	0.84	Often
5. Praying/recitation of mantras before an exam do not guarantee one to score more marks.	3.92	0.95	Often
6. A black cat crossing one's path does not bring bad luck.	4.28	0.80	Always
Category Mean	4.11	0.83	Often

In contrast, the item "Praying/recitation of mantras before an exam does not guarantee one to score more marks" received the lowest mean of 3.92 with a standard deviation of 0.95. While this score still falls under the often manifested category, it reveals that some students may still hold on to certain traditional practices despite acknowledging their lack of scientific basis. This indicates that cultural beliefs may still influence behavior, even among students who otherwise demonstrate strong scientific attitudes.

Overall, the category mean of 4.11 and standard deviation of 0.83 suggest a generally high level of aversion to superstition among the students. This finding highlights a collective tendency to question and move away from beliefs that lack empirical support. The moderate spread of responses indicates that while most students share a similar perspective, there are still varying levels of resistance to superstition within the group.

These findings echo the work of Woolley et al. (2023), who observed that as students develop a deeper understanding of causality and empirical evidence, they increasingly reject superstitious thinking. Similarly, Crossman (2023) emphasized that individuals who prioritize scientific information are less likely to rely on unsupported beliefs and instead favor evidence-based explanations. Therefore, aversion to superstition emerges as a critical element in shaping students' scientific attitudes, as it reflects their commitment to rational inquiry and their ability to evaluate information critically.

Extent of Scientific Attitudes of Students

Table 10 presents the extent of students' scientific attitudes across the given indicators. "Confidence in Scientific Method" recorded the highest mean score of 4.20 with a standard deviation of 0.65, indicating that it is consistently manifested among the students. This suggests that they strongly value systematic experimentation and evidence-based reasoning, which is crucial in cultivating critical thinking, inquiry skills, and reliability in scientific work.

Table 6. *The Extent of Scientific Attitudes of Students*

Items	Mean	SD	Descriptive Equivalent
Rationality	4.14	0.80	Often
Open-mindedness	4.02	0.88	Often
Confidence in Scientific Method	4.20	0.79	Always
Curiosity	4.12	0.80	Often
Aversion to Superstition	4.11	0.83	Often
Overall Mean	4.12	0.82	Often



In contrast, “Open-mindedness” had the lowest mean score of 4.02 and a standard deviation of 0.72, indicating that students are less inclined to readily accept new perspectives or revise their views when confronted with alternative evidence. This relative weakness highlights the importance of encouraging students to be more receptive to diverse ideas and adaptable in scientific discussions, as open-mindedness is fundamental to scientific progress and collaborative problem-solving.

Collectively, the overall mean score of 4.12 with a standard deviation of 0.68 indicates that students generally demonstrated a high level of scientific attitudes. This reflects their logical, inquiry-based, and evidence-driven reasoning skills, coupled with a good skepticism toward unscientific claims. The findings underscore that while students are confident in the scientific method, which is a strength that promotes accuracy and systematic problem-solving, developing greater open-mindedness will be equally essential in fostering holistic scientific literacy and adaptability in real-world contexts.

These results are consistent with those of Fathayati et al. (2024), who found that students with strong scientific attitudes demonstrate higher productivity and adaptability when faced with complex tasks. Similarly, Ince (2023) highlighted that confidence in science enhances persistence and motivation in learning. Taken together, the findings emphasize that nurturing both confidence in the scientific method and open-mindedness is vital for advancing students’ academic engagement, collaborative inquiry, and lifelong problem-solving skills.

Ultimately, the findings show that scientific attitudes positively affect students' learning and engagement. Academic success and essential life-long learning abilities are developed through these attributes, which students need for successful scientific exploration and problem-solving.

Extent of Inquiry-Based Learning Environment in terms of Student Participation

Table 7 presents the extent of the inquiry-based learning environment in terms of student participation. The item “Our science teacher values the answers we give in response to the questions” obtained the highest mean score of 4.31 with a standard deviation of 0.71, indicating that teacher recognition of student responses is consistently practiced and plays a crucial role in fostering students’ confidence and motivation to participate actively in class.

This was followed by the item “Our science teacher encourages us to ask questions about the situations we encounter” with a mean score of 4.29 and a standard deviation of 0.74, and “Our science teacher guides us when we are stuck” with a mean score of 4.20 and a standard deviation of 0.76, both of which are always manifested. These findings highlight the teacher's supportive role in cultivating curiosity and guiding learners through challenges.

Conversely, the item “In our science class, we can easily explain our ideas about the problems related to the subject” received the lowest mean score of 4.00 with a standard deviation of 0.79, suggesting that while participation is generally high, some students may still experience difficulty in articulating their scientific ideas with ease. This points to the need for instructional strategies that further develop students’ communication skills and confidence in expressing their reasoning.

Table 7. *The Extent of Inquiry-Based Learning Environment in Terms of Student Participation*

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. Our science teacher values the answers we give in response to the questions.	4.31	0.75	Always
2. Our science teacher guides us when we are stuck.	4.20	0.84	Always
3. Our science teacher encourages us to ask questions about the situations we encounter.	4.29	0.78	Always
4. Our science teacher values our feelings and thoughts.	4.12	0.80	Often
5. In our science class, we can explain our ideas easily.	4.13	0.80	Often
6. In our science class, we defend our ideas.	4.04	0.77	Often
7. In our science class, we can easily explain our ideas about the problems related to the subject.	4.00	0.78	Often
Category Mean	4.16	0.79	Often

Conversely, the item “In our science class, we can easily explain our ideas about the problems related to the subject” received the lowest mean score of 4.00 with a standard deviation of 0.79, suggesting that while participation is generally high, some students may still experience difficulty in articulating their scientific ideas with ease. This points to the need for instructional strategies that further develop students’ communication skills and confidence in expressing their reasoning.

Taken together, the overall composite mean score of 4.16 with a standard deviation of 0.75 indicates a high level of inquiry-based learning environment in terms of student participation. This implies that the classroom setting not only provides opportunities for learners to think critically and express their ideas but also emphasizes the importance of teacher support in guiding and valuing student contributions, factors essential to sustaining active and meaningful engagement in scientific learning.

The results align with the findings of Gaunkar and Mina (2020), who emphasized that students demonstrate greater autonomy and independence in their learning when immersed in inquiry-based environments. Similarly, Sam (2024) highlighted that such environments not only cultivate critical thinking and problem-solving skills but also foster deeper engagement in scientific inquiry.



Ultimately, these insights suggest that inquiry-based learning promotes active participation, enhances independent learning, and strengthens students’ capacity to approach scientific problems systematically.

Extent of Inquiry-Based Learning Environment in terms of Paying Attention to Ideas

Table 8 presents the extent of the inquiry-based learning environment in terms of paying attention to ideas. Among the indicators, the item “Our science teacher allows me to participate in activities in the classroom as well as other students” had the highest mean of 4.30 and a standard deviation of 0.76, indicating that this practice is consistently observed. This highlights the teacher’s intense effort to ensure inclusivity in classroom activities, giving every student equal opportunities for engagement.

In a similar manner, the items “Our science teacher gives me a hearing in class discussions as much as other students” and “Our science teacher cares about my questions as much as the questions of other students” both had means of 4.27 and standard deviations of 0.80 and 0.76, respectively. These values indicate that students perceive their teachers as attentive and responsive to their voices during class.

Likewise, the items “Our science teacher cares about my opinions as much as the opinions of other students” and “Our science teacher allows me to contribute to the work done in class as much as the other students” each earned a mean of 4.21 with standard deviations of 0.77 and 0.78, respectively, reinforcing that teachers consistently value students’ opinions and contributions in class work.

Table 8. *The Extent of Inquiry-Based Learning Environment in terms of Paying Attention to Ideas*

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. Our science teacher gives me a hearing in class discussions as much as other students.	4.27	0.80	Always
2. Our science teacher cares about my questions as much as the questions of other students.	4.27	0.76	Always
3. Our science teacher cares about my opinions as much as the opinions of other students.	4.21	0.77	Always
4. Our science teacher allows me to contribute to the work done in class as much as the other students.	4.21	0.78	Always
5. Our science teacher encourages me as much as my classmates about the ideas I offer to problems.	4.13	0.79	Always
6. Our science teacher allows me to participate in activities in the classroom as well as other students.	4.30	0.76	Always
Category Mean	4.23	0.78	Always

On the other end, the lowest-rated item was “Our science teacher encourages me as much as my classmates about the ideas I offer to problems,” which achieved a mean of 4.13 with a standard deviation of 0.79. Although still categorized as always manifested, the lower score suggests that there may be fewer instances in which encouragement for individual problem-solving ideas is distributed equitably. This suggests the importance of reinforcing strategies that affirm and motivate all students equally when they contribute ideas to problem-solving tasks.

Overall, the categorical mean of 4.23 with a standard deviation of 0.78 indicates a very high level of inquiry-based learning in terms of attention to ideas. This demonstrates that science teachers create a respectful and inclusive classroom climate where learners’ opinions, questions, and participation are valued, thereby fostering student confidence and engagement in the learning process.

These results echo those of Ivanova and Zhelyazka (2023), who found that students who receive consistent attention to their ideas are more likely to strengthen their conceptual understanding and experimental skills. Likewise, Kruse et al. (2022) highlighted that inclusive, idea-focused classrooms enhance students’ comprehension and engagement. Thus, valuing student voices in inquiry-based learning not only cultivates critical and creative thinking but also advances their scientific literacy.

Extent of Inquiry-Based Learning Environment in terms of Collaboration

Table 9 details the extent of the inquiry-based learning environment in terms of collaboration. Among the indicators, the item “Our science teacher encourages us to express our ideas” had the highest mean of 4.33 and a standard deviation of 0.69, indicating that this practice is consistently observed. This underscores the teacher’s critical role in fostering an open environment where students feel confident articulating their thoughts. Closely following, the item “In our science class, I learn new information from my classmates in the class” reached a mean of 4.31 with a standard deviation of 0.73, indicating that students frequently learn through peer interaction.

Similarly, “In our science class, I work collaboratively with the other students in the class” yielded a mean of 4.28 with a standard deviation of 0.75. In contrast “In our science class, we exchange ideas with our classmates about how to solve problems” earned a mean of 4.20 with a standard deviation of 0.71. These findings reflect the consistent opportunities for teamwork, perspective exchange, and mutual learning in science classrooms.

In contrast, the item “In our science class, I research to defend my opinions on the subject” had the lowest mean of 4.05 with a standard deviation of 0.76. While still categorized as always manifested, this relatively lower rating suggests that independent research to support

personal viewpoints may be less strongly emphasized than collective classroom collaboration. This suggests the importance of further integrating research-oriented activities alongside teamwork to balance independent inquiry with cooperative learning.

Table 9. *The Extent of Inquiry-Based Learning Environment in terms of Collaboration*

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. In our science class, I work collaboratively with the other students in the class.	4.28	0.75	Always
2. In our science class, I help my classmates in the class.	4.17	0.74	Often
3. Our science teacher encourages us to express our ideas.	4.33	0.69	Always
4. In our science class, we exchange ideas with our classmates about how to solve problems.	4.20	0.71	Always
5. In our science class, I research to defend my opinions on the subject.	4.05	0.76	Often
6. In our science class, I share resources with my classmates whom I collaborate with.	4.14	0.76	Often
7. In our science class, I learn new information from my classmates in the class.	4.31	0.73	Always
Category Mean	4.21	0.73	Always

Ultimately, the categorical mean of 4.21 with a standard deviation of 0.73 indicates a very high level of inquiry-based learning environment in terms of collaboration. This highlights that science classrooms are generally successful in promoting cooperative learning, where students communicate, share resources, and support one another. Furthermore, it affirms the teacher's central role in stimulating collaborative practices, which are essential in cultivating teamwork and practical communication skills.

The results support the findings of Lu et al. (2021), who emphasized that collaborative environments enhance higher-order thinking and more effective learning strategies. Likewise, Rannastu-Avalos et al. (2023) noted that students demonstrate improved problem-solving abilities when given opportunities to work with peers. The findings suggest that in an inquiry-based learning environment, collaboration among students enables the development of problem-solving and critical thinking skills, enhanced communication, and effective participation in science-related discussions, and also fosters greater confidence in their scientific inquiry practices.

Extent of Inquiry-Based Learning Environment in terms of Learning

Table 10 elucidates the extent of the inquiry-based learning environment in terms of learning. Notably, the item "In our science class, I am aware that I am responsible for my learning" had the highest mean of 4.30 and a standard deviation of 0.74, indicating that this practice is consistently enacted. This finding underscores the pivotal role of learner autonomy, wherein students acknowledge their accountability for directing and sustaining their own learning trajectories.

Table 10. *The Extent of Inquiry-Based Learning Environment in terms of Learning*

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. In our science class, I can find answers to some problems by using the information I have gathered from research.	4.12	0.74	Often
2. In our science class, I compare the information we obtain with the knowledge I already have.	4.13	0.76	Often
3. In our science class, I use the information we gather to solve new problems.	4.16	0.76	Often
4. In our science class, I question what I learned and how I learned it.	4.12	0.76	Always
5. In our science class, I am aware that I am responsible for my learning.	4.30	0.74	Often
Category Mean	4.17	0.75	Often

Furthermore, the item "In our science class, I use the information we gather to solve new problems" recorded a mean of 4.16 with a standard deviation of 0.76, while "In our science class, I compare the information we obtain with the knowledge I already have" yielded a mean of 4.13 with a standard deviation of 0.76. These results indicate that learners frequently synthesize prior knowledge with new information, thereby facilitating knowledge transfer and application to novel problem contexts.

In contrast, the lowest means were found in the items "In our science class, I can find answers to some problems by using the information I have gathered from research" and "In our science class, I question what I learned and how I learned it," both attaining 4.12 with standard deviations of 0.74 and 0.76, respectively. While still within the often manifested category, these outcomes imply that opportunities for independent inquiry and metacognitive reflection may not be as robustly integrated into classroom practices. This suggests the need to strengthen pedagogical strategies that foreground research-based inquiry and the critical self-examination of learning processes.

Taken as a whole, the categorical mean of 4.17 with a standard deviation of 0.75 indicates a high level of inquiry-based learning. This outcome demonstrates that science classrooms effectively nurture student responsibility, analytical reasoning, and the capacity to process and internalize scientific knowledge.

Corroborating these findings, Yu et al. (2024) affirmed that inquiry-oriented environments cultivate enhanced analytical and reasoning

abilities, thereby sustaining student interest in learning. In parallel, Casa-Coila et al. (2024) emphasized that such contexts deepen conceptual understanding and strengthen problem-solving skills. The findings reaffirm that learning is the cornerstone of inquiry-based environments, where students are positioned not merely as recipients of knowledge but as active constructors of scientific understanding.

Extent of Inquiry-Based Learning Environment in terms of Asking Question

Table 11 highlights the extent of the inquiry-based learning environment in terms of asking questions. Significantly, the item “In our science class, I can easily ask questions to my classmates” recorded the highest mean of 4.03 with a standard deviation of 0.80, demonstrating that students are generally at ease initiating questions within peer interactions. This finding reflects a classroom atmosphere that encourages curiosity and active engagement in collective learning.

Table 11. The Extent of Inquiry-Based Learning Environment in terms of Asking Questions

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. In our science class, I can easily ask questions to my classmates.	4.03	0.80	Often
2. In our science class, my classmates in the class quickly ask me questions.	3.80	0.87	Often
Category Mean	3.92	0.84	Often

On the other hand, the item “In our science class, my classmates quickly ask me questions” yielded the lowest mean of 3.80 with a standard deviation of 0.87, suggesting that reciprocal questioning among peers occurs less frequently. Such a discrepancy points to opportunities for educators to cultivate a more dynamic questioning culture, where students are both confident to ask and respond to inquiries from their peers.

Overall, the categorical mean of 3.92 with a standard deviation of 0.84 indicates a high level of inquiry-based learning in terms of asking questions. These results imply that students are developing foundational questioning skills, yet there remains scope to strengthen mutual inquiry and curiosity, which are essential for a fully participatory inquiry-based classroom.

The findings align with the study of Jagat et al. (2024), who reported that inquiry-based learning environments enhance students’ questioning abilities and engagement in learning. Similarly, Talampas (2023) emphasized that students who regularly pose questions demonstrate higher motivation, active participation, and positive attitudes toward learning. Taken together, these results indicate that fostering questioning in the classroom promotes critical thinking, deepens scientific understanding, and supports active participation in scientific inquiry.

Extent of Inquiry-Based Learning Environment in terms of Observations

Table 12 illustrates the extent of the inquiry-based learning environment through observations. Notably, the item “In our science class, we make observations with my classmates to solve problems” had the highest mean of 4.06 and a standard deviation of 0.78, indicating that collaborative observational activities are consistently enacted. This outcome underscores the importance of empirical engagement, which fosters students’ analytical reasoning and systematic problem-solving.

In addition, the item “In our science class, we discuss the data obtained from the observations with our classmates” yielded a mean of 4.05 with a standard deviation of 0.74, highlighting that data interpretation and peer dialogue are integral to classroom practice. These findings indicate that students are not only engaged in collecting information but also actively participate in interpreting results and exchanging scientific insights, thereby strengthening collaborative inquiry.

Overall, the findings indicate a high level of inquiry-based learning, with a categorical mean of 4.06 and a standard deviation of 0.76. This suggests that the learning environment effectively cultivates skills in evidence-based reasoning, cooperative engagement, and critical analysis, which are essential for the development of scientific literacy.

Table 12. The Extent of Inquiry-Based Learning Environment in terms of Observations

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. In our science class, we make observations with my classmates to solve problems.	4.06	0.78	Often
2. In our science class, we discuss the data obtained from the observations with our classmates.	4.05	0.74	Often
Category Mean	4.06	0.76	Often

These outcomes correspond with the study Corredor et al. (2023), who observed that students with proficient observational skills demonstrate enhanced comprehension and critical thinking. Similarly, Senisum and Edu (2023) emphasized that active engagement in observation contributes to deeper conceptual understanding and more effective participation in science learning. Overall, these findings suggest that systematic observation and collaborative analysis empower students to refine their interpretative skills, advance scientific reasoning, and cultivate more robust scientific attitudes.

Extent of Inquiry-Based Learning Environment in terms of Focusing on Problems

Table 13 presents the extent of the inquiry-based learning environment in terms of focusing on problems. Importantly, the item “In our science class, I am interested in problems related to the subject” had the highest mean of 4.07 and a standard deviation of 0.81, indicating that students are consistently engaged with subject-related challenges. This finding underscores the significance of intrinsic motivation in promoting active engagement with scientific problems.

Table 13. *The Extent of Inquiry-Based Learning Environment in terms of Focusing on Problems*

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. In our science class, I am interested in problems related to the subject.	4.07	0.81	Often
2. I concentrate fully in the science class.	3.97	0.77	Often
Category Mean	4.02	0.79	Often

In contrast, the item “I concentrate fully in the science class” recorded the lowest mean of 3.97 with a standard deviation of 0.77, indicating a slight variation in sustained attention across students. Such an outcome highlights the potential for strategies that further enhance students’ capacity to maintain focus during complex tasks.

Collectively, the categorical mean of 4.02 with a standard deviation of 0.79 indicates a high level of inquiry-based learning in terms of problem-focused learning. These results suggest that students demonstrate interest and attentiveness when engaging with scientific tasks, supporting their development of analytical reasoning, problem-solving, and creative thinking skills.

These findings are consistent with Rumanova et al. (2020), who reported that students who systematically assess and analyze problems are better equipped to derive logical solutions, thereby enhancing academic performance. Similarly, Agustina et al. (2024) emphasized that strong focusing skills contribute to elevated levels of creative thinking during problem-solving activities. Hence, fostering sustained attention and engagement with problems enables students to approach scientific challenges methodically, integrate analytical and creative strategies, and strengthen their overall scientific competence.

Extent of Inquiry-Based Learning Environment

Table 14 presents the overall extent of the inquiry-based learning environment across its indicators. Significantly, the item “paying attention to ideas” achieved the highest mean of 4.23 with a standard deviation of 0.78, indicating that students consistently engage with and value the ideas presented in class. This suggests that the classroom environment effectively cultivates attentiveness and intellectual respect, likely enhancing collaborative learning and fostering critical thinking.

In contrast, the item “asking questions” recorded the lowest mean of 3.92 with a standard deviation of 0.84, indicating that peer and self-initiated questioning is somewhat less frequent. This suggests a potential area for growth, where educators could further encourage reciprocal questioning and curiosity-driven exploration to strengthen students’ inquiry skills and deepen their engagement with scientific concepts.

Table 14. *The Extent of Inquiry-Based Learning Environment*

<i>Indicators</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. Student participation	4.16	0.79	Often
2. Paying attention to ideas	4.23	0.78	Always
3. Collaboration	4.21	0.73	Always
4. Learning	4.17	0.75	Often
5. Asking questions	3.92	0.84	Often
6. Observations	4.06	0.76	Often
7. Focusing on problems	4.02	0.79	Often
Overall Mean	4.11	0.78	Often

Collectively, the overall mean of 4.11 and the standard deviation of 0.78 indicate a high level of inquiry-based learning. These findings suggest that students experience a rich and supportive environment where engagement, collaboration, and respect for diverse ideas are strongly encouraged. In this context, the learning setting not only nurtures active participation but also reinforces the development of analytical, reflective, and problem-solving skills.

The results align with the study by Urdanivia et al. (2023), which emphasized that inquiry-based learning enhances students’ critical thinking, problem-solving abilities, and deeper understanding of scientific concepts through active engagement. Similarly, Kori (2020) highlighted that such environments foster critical thinking and promote active engagement with the subject matter. Ultimately, these findings suggest that exposure to a well-structured inquiry-based learning environment cultivates scientific attitudes, strengthens conceptual understanding, and encourages proof-driven exploration, thereby improving both academic performance and student confidence in science-related tasks.

Cumulatively, these findings indicate that a well-implemented inquiry-based learning environment creates a foundation for students to cultivate scientific attitudes, strengthen conceptual understanding, and engage in evidence-driven exploration. This suggests that consistent exposure to inquiry-based practices not only enhances cognitive and reflective skills but also empowers students to approach

scientific learning with confidence, curiosity, and a proactive mindset.

Extent of Metacognitive Awareness in terms of Students' Declarative Knowledge

Table 15 presents the extent of students' metacognitive awareness regarding declarative knowledge. Of particular significance, the item "I know which information is essential to learn" achieved the highest mean of 4.22 with a standard deviation of 0.76, indicating that students consistently identify crucial information during the learning process. This underscores that students can strategically prioritize content, thereby optimizing their learning efficiency and reinforcing their conceptual understanding.

In contrast, the item "I can remember information well" had the lowest mean of 3.77 and a standard deviation of 0.84, suggesting that retention of information is somewhat less consistently practiced. This highlights a potential pedagogical intervention area, where techniques such as spaced repetition, active recall, or cognitive mapping could enhance memory retention and consolidate learning outcomes.

Table 15. *The Extent of Metacognitive Awareness of Students in terms of Declarative Knowledge*

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. I know which information is essential to learn.	4.22	0.76	Always
2. I can organize information well.	3.90	0.74	Often
3. I can remember information well.	3.77	0.84	Often
4. I can control my learning whether I have learned well or not.	4.03	0.78	Often
5. I can decide whether I have understood something well.	4.07	0.77	Often
Category Mean	4.00	0.78	Often

Overall, the categorical mean of 4.00 and standard deviation of 0.78 indicate a high level of metacognitive awareness regarding declarative knowledge. These findings suggest that students generally possess an acute awareness of their cognitive processes, enabling them to monitor, regulate, and evaluate their learning effectively.

The results correspond with Hwang et al. (2024), who found that students with a robust foundation in declarative knowledge demonstrate superior learning outcomes. Similarly, Bitzenbauer (2021) emphasized that declarative knowledge strengthens students' conceptual grasp and analytical skills. Taken together, these findings imply that cultivating declarative knowledge within metacognitive awareness not only enhances students' strategic learning and information processing but also contributes to the development of scientific reasoning and improved academic performance.

Extent of Metacognitive Awareness in terms of Procedural Knowledge

Table 16 demonstrates the extent of students' procedural knowledge. Of particular relevance, the item "I try to use strategies that have worked previously" attained the highest mean of 4.12 with a standard deviation of 0.79, indicating that students frequently rely on proven strategies in their learning. This suggests that students can recognize practical approaches and apply them systematically, thereby enhancing the efficiency and reliability of their learning processes.

Table 16. *The Extent of Metacognitive Awareness of Students in terms of Procedural Knowledge*

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. I try to use strategies that have worked previously.	4.12	0.79	Often
2. I have a specific purpose for each strategy I use.	4.07	0.76	Often
3. I realized and learned the type of strategy used.	4.04	0.77	Often
4. I found myself using appropriate strategies spontaneously.	3.89	0.82	Often
Category Mean	4.03	0.79	Often

On the other hand, the item "I found myself using appropriate strategies spontaneously" had the lowest mean of 3.89 and a standard deviation of 0.82, suggesting that spontaneous strategy use is somewhat less consistent. This underscores a potential area for development, as fostering adaptive and flexible use of strategies could further strengthen students' procedural proficiency and their capacity to navigate unfamiliar scientific challenges.

Overall, the categorical mean of 4.03 and standard deviation of 0.79 indicate a high level of metacognitive awareness regarding procedural knowledge. These findings indicate that students not only understand various learning strategies but also execute them effectively and confidently, which is essential for problem-solving and the application of scientific concepts.

The results are consistent with those of Butvilas et al. (2023), who reported that procedural knowledge is positively associated with metacognitive awareness, thereby enhancing students' ability to apply learned concepts effectively. Similarly, Ita and Khoiro (2022) emphasized that procedural knowledge facilitates the practical application of scientific concepts, thereby reinforcing students' metacognitive development. Therefore, the development of procedural knowledge equips students to strategically implement and adapt learning strategies across diverse scientific contexts, ultimately promoting problem-solving skills, conceptual application, and strengthened scientific attitudes.

Extent of Metacognitive Awareness in terms of Conditional Knowledge

Table 17 presents the extent of students' metacognitive awareness regarding conditional knowledge. Notably, the item "I can learn better when I know something about the topic" obtained the highest mean of 4.39 with a standard deviation of 0.68, indicating that students consistently benefit from prior understanding of the subject matter. This suggests that possessing preliminary knowledge enhances students' learning efficiency, enabling them to engage with new concepts and strategically scaffold their comprehension.

Alternatively, the item "I know the strategy I use is effective" had the lowest mean of 3.98 and a standard deviation of 0.78, suggesting that students' confidence in the effectiveness of their strategies is somewhat less consistent. This implies a potential area for instructional reinforcement, where explicit feedback and reflection on strategy effectiveness could further consolidate students' ability to adapt their learning approaches.

On top of that, the categorical mean of 4.15 and standard deviation of 0.76 indicate a high level of metacognitive awareness regarding conditional knowledge. These findings indicate that students can exercise deliberate control over their learning processes, adjust strategies to situational demands, and regulate their cognitive strengths and weaknesses.

Table 17. *The Extent of Metacognitive Awareness of Students in terms of Conditional Knowledge*

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. I can learn better when I know something about the topic.	4.39	0.68	Always
2. I use different strategies depending on the situation of the given question.	4.14	0.77	Often
3. I can motivate myself to study if necessary.	4.16	0.80	Often
4. I use intellectual strength to balance my weaknesses.	4.08	0.76	Often
5. I know the strategy I use is effective.	3.98	0.78	Often
Category Mean	4.15	0.76	Often

The results corroborate the study of Pramesti et al. (2023), which emphasized that students with advanced conditional knowledge can effectively integrate appropriate strategies into their learning. Similarly, Tjabolo et al. (2022) highlighted that students who adjust their learning approaches according to context demonstrate superior conditional knowledge. All things considered, the development of conditional knowledge supports students' strategic thinking, enabling them to select and apply appropriate learning methods according to the demands of a task, thereby improving problem-solving capacity, learning quality, and overall metacognitive competence.

Extent of Metacognitive Awareness in terms of Planning Abilities

Table 18 presents the extent of students' metacognitive awareness in terms of planning. Evidently, the item "I read the instructions carefully before starting the task" achieved the highest mean score of 4.35 with a standard deviation of 0.71, indicating that students consistently demonstrate this behavior. This suggests that learners exhibit strong preparatory skills and cognitive organization, allowing them to approach tasks with clarity and structured thinking.

In contrast, the item "I manage my time as best I can to achieve my goals" recorded the lowest mean score of 4.10 and a standard deviation of 0.82, suggesting that, while students generally plan effectively, they experience variability in allocating their time efficiently. This highlights a potential area for targeted support, underscoring the need to enhance time management strategies to optimize academic outcomes.

Table 18. *The Extent of Metacognitive Awareness of Students in terms of Planning*

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. I think about what I have learned before starting an assignment.	4.21	0.79	Always
2. I set certain information before starting a task.	4.17	0.78	Often
3. I will choose the best way to solve the problem.	4.24	0.72	Always
4. I read the instructions carefully before starting the task.	4.35	0.71	Always
5. I manage my time as best I can to achieve my goals.	4.10	0.82	Always
Category Mean	4.21	0.76	Always

Ultimately, the overall mean of 4.21 and standard deviation of 0.76 reflect a high level of metacognitive awareness in planning. These findings denote that students are capable of anticipating task requirements, selecting appropriate approaches, and organizing their learning processes effectively. Such capabilities contribute to improved decision-making and problem-solving during academic activities.

The findings align with the study by Kovalchuk et al. (2023), which emphasized that students with well-developed planning skills demonstrate heightened awareness of their cognitive processes. Similarly, Rinaldi (2021) reported that learners who can identify and apply effective learning strategies in specific situations show enhanced planning proficiency. Taken together, these results underscore that fostering planning skills within metacognitive awareness not only enhances strategic learning and problem-solving capacity but also supports the cultivation of scientific attitudes and academic achievement.

Extent of Metacognitive Awareness in terms of Monitoring Abilities

Table 19 depicts the extent of students' metacognitive awareness in terms of monitoring. Significantly, the item "Before responding to a situation, I explore numerous possibilities" achieved the highest mean score of 4.23 with a standard deviation of 0.77, indicating that students consistently engage in evaluative thinking and deliberate multiple approaches before acting. This reflects their capacity for proactive reflection and strategic planning during learning activities.

Conversely, the item "I learned and reviewed periodically to help myself understand the essential connections of information" received the lowest mean score of 4.06 with a standard deviation of 0.79, suggesting that while students do engage in periodic review, consistency in connecting and integrating information varies. This highlights a potential area for instructional support to reinforce systematic review habits and strengthen conceptual understanding.

Table 19. The Extent of Metacognitive Awareness of Students in terms of Monitoring

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. I often ask myself if I have achieved the learning goal.	4.15	0.78	Often
2. Before responding to a situation, I explore numerous possibilities.	4.23	0.77	Always
3. I question whether I have examined all possible techniques for accomplishing the task.	4.08	0.73	Often
4. I learned and reviewed periodically to help myself understand the essential connections of information.	4.06	0.79	Often
5. I found analyzing the usefulness of different strategies when studying.	4.09	0.76	Often
6. I find that I always pause to reflect on my understanding.	4.13	0.76	Often
Category Mean	4.12	0.77	Often

In aggregate, the category mean of 4.12 and standard deviation of 0.77 indicate a high level of metacognitive awareness in monitoring. This outcome suggests that students generally demonstrate strong reflective capabilities, can evaluate their comprehension, and can regulate their learning processes effectively. These competencies are essential for fostering self-directed learning and enhancing academic performance.

The findings correspond with Samuel (2023), who reported that learners with well-developed monitoring skills can adjust their learning strategies and assess their progress even outside formal classroom settings. Similarly, Xiong and Noichun (2022) emphasized that active engagement in reflective practices strengthens self-monitoring, enabling learners to adapt strategies to optimize comprehension. In conclusion, cultivating monitoring skills promotes autonomous learning, enhances problem-solving aptitude, and reinforces scientific reasoning in inquiry-based educational contexts.

Extent of Metacognitive Awareness in terms of Evaluation

Table 20 presents the extent of students' metacognitive awareness regarding evaluation. To further emphasize, the item "After completing the task, I asked myself if there was an easy way to complete the job" attained the highest mean of 4.13, suggesting that students frequently engage in reflective evaluation to identify more efficient strategies for task completion. This highlights their ability to assess their approaches and optimize their learning outcomes critically.

Table 20. The Extent of Metacognitive Awareness of Students in terms of Evaluation

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. I know the extent of self-achievement after completing a test.	4.09	0.80	Often
2. After completing the task, I asked myself if there was an easy way to complete the job.	4.13	0.75	Often
3. After studying, I always summarize what I have learned.	4.01	0.80	Often
4. After completing a task, I ask myself how far I have achieved my goals.	4.01	0.78	Often
5. I asked myself if I had learned any additional knowledge after completing the assignment.	4.12	0.75	Often
Category Mean	4.07	0.78	Often

Meanwhile, the items "After studying, I always summarize what I have learned" and "After completing a task, I ask myself how far I have achieved my goals" received the lowest mean score of 4.01, indicating that although students consistently perform summarization and goal assessment, there remains a marginal gap in regularity and depth of evaluative practice. This leads to a potential area for strengthening systematic reflection and performance monitoring.

The overall mean of 4.07 indicates a high level of metacognitive awareness in evaluation. This demonstrates that students actively engage in evaluative thinking, particularly after completing tasks, enabling them to monitor their progress, reflect on their learning, and adjust their strategies as needed.

The findings support those of Muhammad et al. (2024), who asserted that students with strong self-evaluation skills are better able to engage in independent learning and accurately identify areas for improvement. Similarly, Gladovic et al. (2023) emphasized that



reflective assessment enhances students’ capacity to appraise their tasks and adhere to quality standards critically.

Additionally, Seden et al. (2023) highlighted that students with robust evaluative abilities demonstrate heightened self-awareness and precise performance assessment. Consequently, through consistent self-assessment, students strengthen their metacognitive competence, cultivate scientific attitudes, and develop critical thinking skills while adapting effectively to diverse learning contexts.

Extent of Metacognitive Awareness of Students

Table 21 presents the extent of students’ metacognitive awareness across the examined dimensions. “Planning” recorded the highest mean score of 4.21 with a standard deviation of 0.76, indicating that it is consistently manifested among the students. This suggests that they effectively organize, anticipate, and regulate their learning tasks, demonstrating strong strategic thinking and self-directed control over their academic performance.

In contrast, “Declarative Knowledge” had the lowest mean score of 4.00, with a standard deviation of 0.78, suggesting that students are somewhat less consistent in mastering and internalizing essential information. This relative weakness highlights the need to strengthen further students’ foundational knowledge to support the practical application of cognitive strategies and enhance overall learning efficiency.

Table 21. The Extent of Metacognitive Awareness of Students

<i>Indicators</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. Declarative Knowledge	4.00	0.78	Often
2. Procedural Knowledge	4.03	0.79	Often
3. Conditional Knowledge	4.15	0.76	Often
4. Planning	4.21	0.76	Always
5. Monitoring	4.12	0.77	Often
6. Evaluation	4.07	0.78	Often
Overall Mean	4.10	0.77	Often

Overall, the mean score of 4.10 with a standard deviation of 0.77 suggests that students exhibit a substantial level of metacognitive awareness. This demonstrates their ability to not only recognize and comprehend their own cognitive processes but also to strategically regulate and orchestrate their learning activities. Moreover, it indicates that students are capable of setting goals, selecting appropriate strategies, monitoring their progress, and reflecting on outcomes to optimize understanding and performance.

These findings align with those of Durukan et al. (2022), who noted that students with elevated metacognitive awareness can adapt their strategies and reflect on their learning, thereby promoting academic self-regulation. Similarly, Stanton et al. (2021) emphasized that awareness of one’s own thinking enhances independence and preparedness for diverse academic challenges. In addition, Hartelt and Martens (2024) highlighted that students who are conscious of their cognitive processes approach learning tasks with greater confidence, while Gutierrez de Blume et al. (2024) noted that monitoring and evaluating one’s learning facilitates improved self-management and academic outcomes.

All things considered, students cultivate stronger scientific attitudes through metacognitive awareness, as it fosters autonomous learning and adaptability in facing academic challenges. The findings indicate that students who engage in reflective thinking and self-assessment develop greater confidence in employing effective learning strategies, which, in turn, enhances their ability to solve problems independently. Moreover, academic performance and outcomes in science education are strengthened when students actively monitor their learning processes and make strategic adjustments to optimize their study habits.

Extent of Critical Thinking of Students in terms of Remembering

Table 22 presents the extent of students’ critical thinking in terms of remembering. The results reveal that the items “After reading it, I am able to repeat important threads from the text” and “If necessary, I can recall information about which I once read” both received the highest mean score of 3.89, indicating that students frequently demonstrate these abilities. The corresponding standard deviations, 0.84 and 0.82, respectively, suggest moderate variability in students’ performance, indicating that although most students are proficient at recalling key information, some variation exists in their memory retention strategies.

Table 22. The Extent of Critical Thinking of Students in Terms of Remembering

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. After reading it, I am able to repeat important threads from the text.	3.89	0.84	Often
2. If necessary, I can recall information about which I once read.	3.89	0.82	Often
3. I can remember much from what I was learning at school.	3.82	0.82	Often
Category Mean	3.87	0.83	Often

In contrast, the item “I can remember much from what I was learning at school” had the lowest mean score of 3.82, indicating frequent manifestation but slightly lower consistency, suggesting that some students may experience challenges in retaining information over longer periods or across different contexts. Collectively, the overall mean score of 3.87, accompanied by a standard deviation of 0.83, indicates that students generally demonstrate a high level of proficiency in retrieving and recalling previously learned information.



The relatively moderate variability, as reflected in the SD, suggests that while most students are consistently capable of recalling essential concepts, there is some variation in the degree of mastery across the group. This proficiency in remembering not only reflects competence in the foundational cognitive domain but also lays a critical foundation for higher-order thinking.

These findings align with the study by Murphy and Castel (2021), which emphasized that students with strong recall abilities exhibit improved conceptual understanding and demonstrate greater learning efficacy. Likewise, Wardani et al. (2024) observed that robust remembering skills enhance students' performance even within conventional learning environments. In addition, Zaidi and Zaidi (2022) highlighted that students with well-developed memory capacities are better able to retain and apply knowledge, thereby positively influencing their academic outcomes.

Therefore, the ability to effectively retrieve prior knowledge enables students to synthesize information, build deeper conceptual understanding, and enhance problem-solving abilities. Furthermore, students with well-honed memory skills are more adept at retaining essential scientific information, thereby strengthening their reasoning and decision-making capacities in scientific contexts.

Extent of Critical Thinking of Students in terms of Understanding

Table 23 shows students' understanding of critical thinking. The findings show that the item “I like to collate different opinions and compare them with each other” received the highest mean score of 4.02 with a standard deviation of 0.79, indicating that it is often manifested. This suggests that students consistently engage in comparing ideas, demonstrating their ability to synthesize information from various sources and develop interpretive and evaluative thinking.

Meanwhile, the item “I have no problem with paraphrasing” had the lowest mean score of 3.74 and a standard deviation of 0.89, indicating that it is also often manifested. This implies that some students experience variability in expressing ideas in their own words, indicating a need for reinforcement in paraphrasing skills to strengthen comprehension and communication.

Table 23. The Extent of Critical Thinking of Students in terms of Understanding

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. I can understand texts from various fields.	3.83	0.84	Often
2. I like to collate different opinions and compare them with each other.	4.02	0.79	Often
3. I have no problem with paraphrasing.	3.74	0.89	Often
4. I pay attention to the contexts, nuances, and overtones of the statements.	3.92	0.83	Often
Category Mean	3.88	0.84	Often

Based on the results, students' understanding skills received an overall mean score of 3.88 with a standard deviation of 0.84, indicating a high level of comprehension. This reflects their ability to grasp key concepts and effectively interpret, organize, and synthesize information. The standard deviation suggests that while most students demonstrate consistent comprehension, some may benefit from additional support to achieve uniform proficiency. Overall, these findings highlight the significance of strong understanding skills as a critical component of cognitive and analytical development.

The results align with those of Suharto et al. (2020), who found that students with strong understanding skills demonstrate better conceptual comprehension and academic engagement. Similarly, Widinda (2020) emphasized that high-level understanding supports scientific writing and idea organization. Additionally, Sutirna and Safuri (2023) noted that students with well-developed comprehension skills tend to demonstrate improved practical skills and positive scientific attitudes. Overall, fostering both comparative analysis and paraphrasing abilities is essential for enhancing students' critical thinking and practical application of scientific knowledge.

Extent of Critical Thinking of Students in terms of Analyzing

Table 24 shows students' critical thinking in terms of analysis. The findings indicate that the item “I like finding connections between seemingly different phenomena” received the highest mean score of 3.95 with a standard deviation of 0.78, suggesting that it is often manifested. This implies that students actively engage in identifying relationships across concepts, demonstrating their capacity to synthesize knowledge and connect ideas from diverse contexts.

On the other hand, the item “I like making an in-depth analysis of reality” obtained the lowest mean score of 3.84 with a standard deviation of 0.88, indicating that it is also often manifested. This reflects a slight variation in students' ability to conduct thorough, critical examinations of real-world situations, suggesting that some students may benefit from additional guidance in applying deeper analytical thinking.

Table 24. The Extent of Critical Thinking of Students in terms of Analyzing

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. I like making an in-depth analysis of reality.	3.84	0.88	Often
2. I like finding connections between seemingly different phenomena.	3.95	0.78	Often
3. I can extract the most relevant parts of a text.	3.86	0.81	Often
4. When I read the text, I am researching for a relationship between the information it contains and other texts that I have read.	3.94	0.77	Often
Category Mean	3.90	0.81	Often



As reflected in the findings, students’ analytical skills had an overall mean score of 3.90 and a standard deviation of 0.81, indicating a high level of analytical proficiency. The standard deviation suggests that while most students demonstrate consistent analytical skills, some may require additional support to achieve comparable proficiency. Overall, these findings highlight the importance of developing strong analytical abilities to strengthen students’ problem-solving, reasoning, and scientific conceptual understanding.

The results align with Wynn (2024), who emphasized that students with refined analytical skills can critically evaluate concepts and solve complex problems more effectively. Similarly, Suyatman et al. (2021) indicated that strong analytical skills enhance students’ ability to interpret scientific concepts and derive practical solutions. Moreover, Toleva-Stoimenova and Rasheva-Yordanova (2023) noted that students with advanced analytical capacities demonstrate improved decision-making abilities and a better grasp of scientific understanding, which positively impacts their academic outcomes and preparedness for real-world challenges.

Extent of Critical Thinking of Students in terms of Applying

Table 25 demonstrates the extent of students’ critical thinking in terms of applying. The item “I am willing to share my newly gained information” received the highest mean score of 4.22 with a standard deviation of 0.76, indicating that it is consistently manifested. This suggests that students actively engage in sharing knowledge, demonstrating confidence in their learning and a strong capacity for collaboration and practical application of concepts. On the contrary, the item “When I talk, I give many examples” had the lowest mean score of 3.99 and a standard deviation of 0.82, indicating that it is often manifested. This implies that, while students generally provide examples to support their ideas, there is some variability in their ability to consistently illustrate concepts, suggesting a need for reinforcement in linking theory to practical examples.

Table 25. *The Extent of Critical Thinking of Students in terms of Applying*

Items	Mean	SD	Descriptive Equivalent
1. I am willing to share my newly gained information.	4.22	0.76	Always
2. When I talk, I give many examples.	3.99	0.82	Often
3. When discussing, I try to use practical examples to justify my stance on the matter.	4.12	0.76	Often
4. I try to use the information I have learned in everyday life.	4.10	0.77	Often
Category Mean	4.11	0.78	Often

In light of the results, students’ applying skills achieved an overall mean score of 4.11 with a standard deviation of 0.78, reflecting a high level of ability to translate knowledge into practice. This demonstrates that students not only grasp theoretical concepts but also can apply them in practical, real-world, and collaborative contexts. The standard deviation indicates moderate consistency among students, though some may benefit from additional guidance to better apply the examples. Overall, these findings underscore the importance of fostering practical knowledge application as a critical component of critical thinking and problem-solving.

The results support Jamir’s (2023) findings, which noted that students with advanced application skills display greater competence and adaptability in real-world contexts. Similarly, Tomory (2023) emphasized that effective knowledge application enhances practical skills and soft competencies. Chaudhari and Deshpande (2023) also noted that students with strong application skills can integrate theoretical knowledge into professional and everyday contexts. Furthermore, Patra et al. (2022) concluded that innovative teaching strategies enhance students’ ability to apply knowledge, thereby strengthening their critical thinking and problem-solving skills.

Extent of Critical Thinking of Students in terms of Evaluating

Table 26 shows students’ critical thinking in evaluating. The findings indicate that the item “When I am interested in some information, I try to check if it is true” had the highest mean score of 4.35 and a standard deviation of 0.72, suggesting it is consistently manifested. This demonstrates that students actively engage in fact-checking, showing a strong inclination to verify information and to exercise critical judgment in both academic and real-world contexts. Their ability to validate sources and question information reflects a high level of evaluative skill, which is essential for informed decision-making and reflective thinking.

Table 26. *The Extent of Critical Thinking of Students in terms of Evaluating*

Items	Mean	SD	Descriptive Equivalent
1. In the discussion, I care about justifying my stance on the matter and understanding the other party at the same time.	4.12	0.75	Often
2. When I am interested in some information, I try to check if it is true.	4.35	0.72	Always
3. After reading, I check important information, even if it seems to be true.	4.23	0.72	Always
4. To evaluate the information, I check many sources.	4.14	0.78	Often
Category Mean	4.21	0.74	Always

Contrarily, the item “In the discussion, I care about justifying my stance on the matter and understanding the other party at the same time” obtained the lowest mean score of 4.12 with a standard deviation of 0.75, indicating that it is often manifested. This implies that, while students are generally able to justify their opinions and consider alternative perspectives, there is some variability in their ability to balance assertiveness with openness during discussions. Targeted support in collaborative evaluation and perspective-taking could further enhance their evaluative competence.

Collectively, the overall mean score of 4.21 with a standard deviation of 0.74 reflects a very high level of critical thinking in the evaluating dimension. This suggests that students not only assess information rigorously but also integrate reflective judgment and logical reasoning into their academic practices. The findings indicate that students are capable of distinguishing factual content from assumptions or bias, supporting their ability to make informed decisions and strengthen scientific reasoning.

These results are consistent with Wanzer (2020), who found that students with strong evaluative skills make more informed decisions and develop higher-order critical thinking skills. Similarly, Shenton (2024) emphasized that practical evaluation enables students to identify and use relevant information appropriately. Furthermore, Pimentel (2024) and Cekule and Cekuls (2022) noted that students who verify sources and critically assess content demonstrate better reflective thinking and decision-making abilities. Overall, cultivating evaluation skills enhances students' capacity to handle complex information, make logical judgments, and achieve greater academic and scientific competence.

Extent of Critical Thinking of Students in terms of Creating

Table 27 presents the extent of students' critical thinking in terms of creating. The item "I like combining information from different texts" obtained the highest mean score of 4.08 with a standard deviation of 0.81, indicating that it is often manifested. This suggests that students frequently integrate information from multiple sources, demonstrating their capacity to synthesize ideas and engage in creative reasoning. Such skills enable them to approach problems innovatively and generate original solutions in academic and scientific contexts.

On the other hand, the item "I can change the structure of the text after reading it" had the lowest mean score of 3.81 and a standard deviation of 0.86, indicating that it is often manifested. This suggests that some students may experience challenges with restructuring or reinterpreting information, indicating an area for further development in flexible and adaptive thinking.

Table 27. The Extent of Critical Thinking of Students in terms of Creating

<i>Items</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. I like combining information from different texts.	4.08	0.81	Often
2. I like expressing the same content in many different ways.	4.02	0.77	Often
3. I like form my impression on the basis of various information that I combine with each other.	4.02	0.73	Often
4. Everything that exists can be changed or improved to create something new.	4.12	0.74	Often
5. I can change the structure of the text after reading it.	3.81	0.86	Often
6. I like discussing new meanings in texts that I already know.	4.06	0.79	Often
Category Mean	4.02	0.78	Often

As indicated in the findings, the mean score of 4.02 with a standard deviation of 0.78 reflects a high level of creative critical thinking among students. It indicates that learners are generally capable of combining knowledge, reimagining content, and viewing information from different perspectives. The standard deviation indicates that while most students consistently demonstrate creative skills, some may require additional guidance to achieve comparable proficiency.

These findings align with Alsaleh (2020), who highlighted that students who generate innovative solutions demonstrate strong creative thinking abilities. Wulandari et al. (2024) similarly emphasized that reasoning skills underpin creative learning, while Arifianti and Baidawi (2024) noted that problem-solving in open-ended contexts fosters innovation. Additionally, Akmam et al. (2024) revealed that engaging with complex material enhances students' creativity. Overall, nurturing creative thinking enables learners to devise novel solutions, integrate multiple perspectives, and strengthen both scientific reasoning and practical problem-solving abilities.

Extent of Critical Thinking of Students

Table 28 presents the overall extent of students' critical thinking. The item "Evaluating" received the highest mean score of 4.21 with a standard deviation of 0.74, indicating that it is consistently manifested among the students. This suggests that students actively engage in assessing information, reflecting on outcomes, and making reasoned judgments. The relatively lower standard deviation further implies that most students demonstrate consistent proficiency in evaluation, highlighting their strength in higher-order critical thinking and their ability to appraise information and make informed decisions critically.

Table 28. The Extent of Critical Thinking of Students

<i>Indicators</i>	<i>Mean</i>	<i>SD</i>	<i>Descriptive Equivalent</i>
1. Remembering	3.87	0.83	Often
2. Understanding	3.88	0.84	Often
3. Analyzing	3.90	0.81	Often
4. Applying	4.11	0.78	Often
5. Evaluating	4.21	0.74	Always
6. Creating	4.02	0.78	Often
Overall Mean	4.00	0.80	Often

In contrast, the item "Remembering" recorded the lowest mean score of 3.87 with a standard deviation of 0.83, indicating that it is

often demonstrated. This shows that while students can retrieve previously learned information, there is slightly greater variability in performance compared to evaluating skills. Some students may need additional reinforcement to achieve uniform proficiency in recalling foundational knowledge, which is essential for building more complex cognitive processes.

Overall, the students' critical thinking skills are demonstrated by a total mean score of 4.00 with a standard deviation of 0.80, indicating a generally high level of competence. The observed upward trend in mean scores across lower- and higher-order cognitive domains suggests that students are not only able to recall and understand foundational knowledge but are also advancing toward more sophisticated cognitive processes. This progression encompasses the ability to apply learned concepts in practical contexts, analyze relationships and patterns within information, evaluate the validity and relevance of ideas, and create new solutions or perspectives.

These findings align with previous studies indicating that academically strong students consistently demonstrate advanced critical thinking abilities. For instance, Yau et al. (2023) observed that high-achieving students exhibit heightened critical thinking, whereas Garcia Carmona (2023) emphasized the integral role of scientific reasoning in its development. Similarly, Le (2024) highlighted that students who make informed decisions tend to show more sophisticated critical thinking, and Verawati et al. (2024) identified the capacity to discern valuable information as a hallmark of effective critical thinkers.

Altogether, these studies underscore that well-cultivated critical thinking, particularly in the evaluative domain, enhances logical reasoning, evidence-based decision-making, and independent problem-solving. Consequently, such skills not only reinforce students' scientific attitudes but also equip them to navigate complex academic tasks and real-world challenges with competence and discernment.

Relationships between the Variables

Table 29 presents the Pearson correlation coefficients and corresponding p-values for the study variables. The results indicate that all six correlations are statistically significant, providing strong evidence of meaningful associations and leading to the rejection of the null hypotheses.

Primarily, the relationship between the inquiry-based learning environment and students' scientific attitudes demonstrates a strong positive correlation ($r = 0.642$, $p = 0.000$), which falls below the conventional significance threshold of 0.05. This finding corroborates the study of Manishimwe et al. (2022), which reported that students who actively ask questions and articulate their thoughts exhibit more positive scientific attitudes. Accordingly, engagement in inquiry-oriented tasks enhances students' appreciation for and disposition toward learning science.

Table 29. *Relationships between the Variables*

<i>Variables Correlated</i>	<i>R</i>	<i>p-value</i>	<i>Decision on Ho</i>	<i>Decision on Relationship</i>
Inquiry-based learning environment and scientific attitudes of students	.642	.000	Reject	Significant
Metacognitive awareness and scientific attitudes of students	.707	.000	Reject	Significant
Critical thinking and scientific attitude of students	.731	.000	Reject	Significant
Inquiry-based learning environment and critical thinking of students	.655	.000	Reject	Significant
Metacognitive awareness and critical thinking of students	.800	.000	Reject	Significant
Inquiry-based learning environment and metacognitive awareness of students	.799	.000	Reject	Significant

Furthermore, metacognitive awareness exhibits a very strong positive correlation with scientific attitudes, with an r value of 0.707 and a p value of 0.000. This observation aligns with Abdelrahman (2020), who emphasized that students with higher metacognitive awareness demonstrate greater academic motivation, achievement, and well-developed scientific attitudes. Therefore, students who are more cognizant of their own cognitive processes tend to develop stronger scientific attitudes and display greater engagement in science learning.

In a similar vein, critical thinking shows a very strong positive correlation with scientific attitudes, with an r value of 0.731 and a p value of 0.000. This result is consistent with Pursitasari et al. (2023), who found that students with higher critical thinking skills engage more effectively with scientific concepts and are more willing to apply scientific approaches in problem-solving. Hence, critical thinking not only enhances students' reasoning abilities but also reinforces their attitudes toward scientific practices and beliefs.

Moreover, the correlation between inquiry-based learning environments and critical thinking is strong, with an r value of 0.655 and a p value of 0.000. Wale and Bishaw (2020) reported that students who actively participate in discussions and activities demonstrate improved critical thinking, while Hogan (2024) highlighted that opportunities for students to express ideas and solve problems cultivate confidence and higher-order thinking skills. Consequently, a learning environment that fosters inquiry enhances students' critical thinking through active engagement and problem-solving.

Notably, the strongest correlation is observed between metacognitive awareness and critical thinking, with an r value of 0.800 and a p value of 0.000. This finding is supported by Rivas et al. (2022), who emphasized the interdependence of these skills, and Leasa (2024), who noted that students engaging in tasks requiring higher-order thinking develop greater awareness of their cognitive processes. Thus, students who regulate and reflect on their learning are better able to engage in critical analysis and reasoning.

Finally, the relationship between inquiry-based learning environments and metacognitive awareness shows a robust positive correlation ($r = 0.799$, $p = 0.000$). This aligns with Pambudi et al. (2022), who found that students exposed to inquiry-based learning demonstrate significantly enhanced metacognitive skills, and Wang et al. (2021), who indicated that such environments improve students' ability to plan, monitor, and evaluate their learning. Accordingly, an inquiry-oriented learning environment simultaneously fosters metacognitive awareness and higher-order thinking skills.

Ultimately, Pearson's r correlation reveals that all six correlations are statistically significant at the 0.000 level, show positive correlations, and demonstrate a strong to extreme degree of association. Thus, the results portray a strong interconnected relationship among inquiry-based learning environment, metacognitive awareness, critical thinking and scientific attitudes. Each variable supports and enhances the others, demonstrating a synergistic effect in the learning process.

Significant Predictors of Scientific Attitude of Students

Table 30 presents the results of the multiple linear regression analysis used to determine the significant predictors of students' scientific attitudes. The model includes inquiry-based learning environment, metacognitive awareness, and critical thinking as predictors.

Table 30. Test of Significant Predictors of Scientific Attitude of Students

Model	Unstandardized Coefficients		Standardized Coefficients	T	p-value	Decision on H_0 $\alpha=0.05$
	β	SE	β			
(Constant)	.981	.118		8.33	.000	
Inquiry-based Learning Environment	.189	.045	.194	4.21	.000	Reject
Metacognitive Awareness	.181	.055	.191	3.29	.001	Reject
Critical Thinking	.404	.041	.451	9.76	.000	Reject
Model Summary: $R = .768$; $R^2 = .590$; $F = 256.148$; $p = .000$						

With respect to individual predictors, an inquiry-based learning environment is a significant predictor of scientific attitudes, as indicated by an unstandardized coefficient of 0.189. This implies that for every one-unit increase in inquiry-based learning environment, scientific attitudes increase by 0.189 units, holding other variables constant. The standardized coefficient of 0.194 reflects a moderate positive contribution to the model. Moreover, the predictor is statistically significant, with a t value of 4.21 and a p value of 0.000, leading to the rejection of the null hypothesis.

Similarly, metacognitive awareness significantly predicts scientific attitudes. Its unstandardized coefficient of 0.181 indicates a positive contribution, while the standardized coefficient of 0.191 shows a relative effect comparable to that of an inquiry-based learning environment. Additionally, the predictor is statistically significant, with a t value of 3.29 and a p value of 0.001, leading to rejection of the null hypothesis.

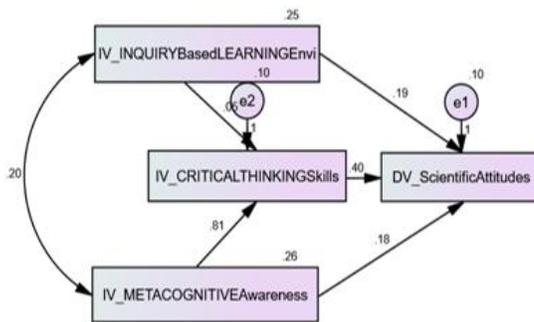
In comparison, critical thinking shows the most potent predictive effect among the three variables. The unstandardized coefficient of 0.404 indicates that a one-unit increase in critical thinking is associated with a 0.404-unit increase in scientific attitudes. Its standardized coefficient of 0.451 is the highest, indicating the most significant influence on scientific attitudes. Consequently, the predictor is highly statistically significant, with a t value of 9.76 and a p value of 0.000, thus rejecting the null hypothesis.

Taken together, the results indicate that all three predictors, namely, inquiry-based learning environment, metacognitive awareness, and critical thinking, significantly contribute to explaining variations in students' scientific attitudes, with critical thinking exerting the most decisive influence.

The findings suggest that cognitive and instructional factors play a vital role in shaping students' attitudes toward science. Further, the results also highlighted that fostering critical thinking should be prioritized in curriculum and instruction. Also, designing inquiry-based activities and promoting metacognitive strategies can holistically develop not just the scientific knowledge but also positive dispositions toward learning science. On top of that, educators and curriculum planners should also consider these predictors as essential for improving scientific engagement and literacy.

Model Fit Summary

This section presents the results of the path analysis, highlighting the hypothesized models and best-fit model, along with their corresponding fit indices to assess model adequacy. Figure 1 illustrates the hypothesized model in which the inquiry-based learning environment, metacognitive awareness, and critical thinking are posited to be associated with scientific attitudes. The model further depicts the hypothesized effects of inquiry-based learning and metacognitive awareness on critical thinking. Additionally, it highlights the reciprocal relationship between the inquiry-based learning environment and metacognitive awareness.



INDEX	MODEL FIT VALUE
CMIN/DF	-
p-value	-
NFI	1.000
RFI	-
TLI	-
CFI	1.000
RMSEA	.698
PCLOSE	.000

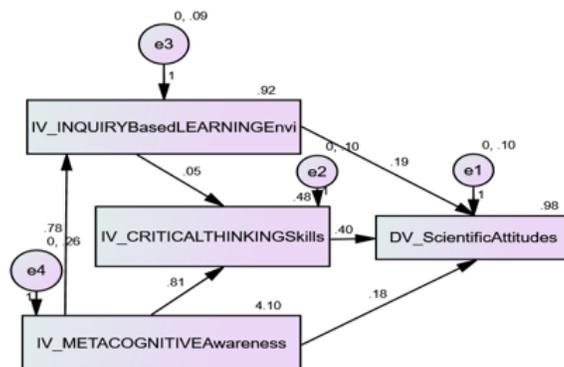
Figure 1. Hypothesized Model 1

Based on the results, critical thinking exerts the most substantial influence on the endogenous variable, scientific attitudes, as indicated by a path coefficient of 0.40. In contrast, both the inquiry-based learning environment and metacognitive awareness exhibit relatively weak influences on scientific attitudes, with path coefficients of 0.19 and 0.18, respectively. Furthermore, metacognitive awareness has a substantial effect on critical thinking, as reflected in a path coefficient of 0.81, whereas the influence of the inquiry-based learning environment on critical thinking is minimal, with a path coefficient of 0.06. Additionally, the relationship between the inquiry-based learning environment and metacognitive awareness appears weak with a path coefficient of .20.

Although some fit indices, such as the Normed Fit Index and the Comparative Fit Index, both equal to 1.000, suggest a good fit, the model overall does not adequately represent the data. The Root Mean Square Error of Approximation is 0.698, which is well above the recommended threshold of 0.08, and the PCLOSE value is 0.000, indicating poor approximation.

These results suggest that specific paths, particularly those between inquiry-based learning and critical thinking or between inquiry-based learning and metacognitive awareness, contribute minimally to explaining students' scientific attitudes. Therefore, additional factors not included in the model may play a significant role in shaping students' scientific attitudes, highlighting the need for further investigation.

Figure 2 shows the relationship between inquiry-based learning environment, metacognitive awareness and critical thinking towards scientific attitudes. Additionally, the diagram also shows the direct effect of metacognitive awareness towards inquiry-based learning environment.



INDEX	MODEL FIT VALUE
CMIN/DF	-
p-value	-
NFI	1.000
RFI	-
TLI	-
CFI	1.000
RMSEA	.698
PCLOSE	.000

Figure 2. Hypothesized Model 2

The results indicate that critical thinking has the most substantial influence on their scientific attitudes, with a path coefficient of 0.40. In comparison, inquiry-based learning environment and metacognitive awareness show weaker influences on scientific attitudes, with path coefficients of 0.19 and 0.18, respectively. Furthermore, metacognitive awareness strongly supports the development of critical thinking, as reflected by a path coefficient of 0.81. At the same time, the inquiry-based learning environment has a minimal effect on critical thinking, with a path coefficient of 0.05. Additionally, metacognitive awareness strongly influences an inquiry-based learning environment, with a path coefficient of 0.78.

Despite the perfect NFI and CFI values of 1.000, the model exhibits poor fit, with an RMSEA of 0.698 and a PCLOSE of 0.000. RMSEA values above 0.08 indicate substantial misfit, and a PCLOSE below 0.05 confirms that the model poorly approximates the population covariance matrix. The absence of CMIN/DF, p-value, RFI, and TLI values limits a complete evaluation. However, the elevated RMSEA and significant PCLOSE clearly demonstrate that the model does not adequately represent the observed data. This shows that the current model may not fully capture the relationships among students' inquiry-based learning environment, metacognitive awareness, critical thinking, and scientific attitudes, suggesting a need to refine or include additional variables to explain students' learning experiences better.

Figure 3 illustrates the relationships among the inquiry-based learning environment, critical thinking, and metacognitive awareness in shaping students' scientific attitudes. Furthermore, it highlights that the inquiry-based learning environment exhibits a reciprocal relationship with critical thinking. Similarly, metacognitive awareness also maintains a reciprocal relationship with critical thinking, indicating bidirectional influences between the two variables.

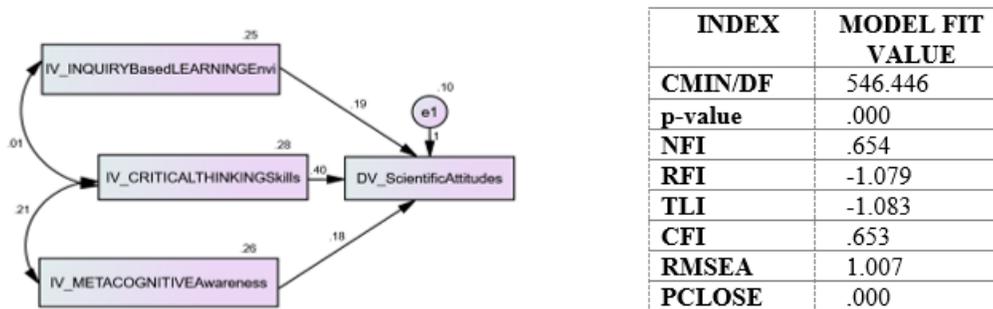


Figure 3. Hypothesized Model 3

The results show that critical thinking had the most decisive influence on scientific attitudes, with a path coefficient of .40. On the other hand, the Inquiry-Based learning environment and metacognitive awareness both demonstrate weak influence on scientific attitudes, with path coefficients of .19 and .18, respectively. Meanwhile, the inquiry-based learning environment and critical thinking have the weakest influence on each other, with a path analysis of .01. At the same time, metacognition also exhibits a weak reciprocal relationship with critical thinking, with a path analysis of .21.

The results indicate that critical thinking exerts the most decisive influence on scientific attitudes, with a path coefficient of 0.40. In contrast, the inquiry-based learning environment and metacognitive awareness demonstrate relatively weak influences on scientific attitudes, with path coefficients of 0.19 and 0.18, respectively. Furthermore, the reciprocal influence between the inquiry-based learning environment and critical thinking is minimal, with a path coefficient of 0.01. In contrast, metacognitive awareness shows a weak reciprocal relationship with critical thinking, with a path coefficient of 0.21. Even with low NFI and CFI values of 0.654 and 0.653, the model exhibits poor fit, as indicated by a high RMSEA of 1.007 and a PCLOSE of 0.000. RMSEA values above 0.08 indicate substantial misfit, and a PCLOSE below 0.05 confirms that the model poorly approximates the population covariance matrix. Furthermore, the high CMIN/DF of 546.446, a p-value of 0.000, and negative RFI and TLI values further highlight the model's inadequacy in representing the data.

These imply that the current model does not adequately capture the relationships among students' inquiry-based learning environment, metacognitive awareness, critical thinking, and scientific attitudes, underscoring the need to refine the model or include additional variables to explain students' learning experiences better.

Figure 4 illustrates the hypothesized relationships among critical thinking, metacognitive awareness, and scientific attitudes. Additionally, it depicts the direct influence of the inquiry-based learning environment on metacognitive awareness. Moreover, critical thinking directly influences both the inquiry-based learning environment and metacognitive awareness.

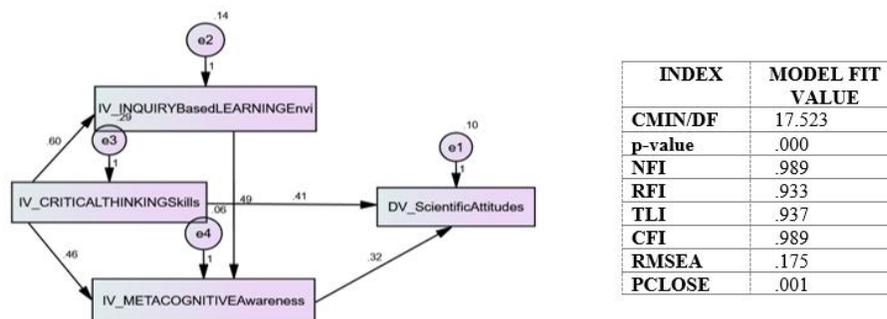


Figure 4. Hypothesized Model 4

The results of the model indicate that critical thinking exerts the strongest influence on the inquiry-based learning environment, with a path coefficient of 0.60. It also demonstrates a moderate influence on both metacognitive awareness and scientific attitudes, with path coefficients of 0.46 and 0.41, respectively. In like manner, the inquiry-based learning environment exhibits a moderate influence on metacognitive awareness, with a path coefficient of 0.49.

The model is not a good fit for the data. Despite the NFI of 0.989 and CFI of 0.989 suggesting acceptable incremental fit, the absolute fit indices indicate serious misfit. The CMIN/DF of 17.523 is far above the recommended threshold of 3, and the p-value of 0.000 indicates a significant discrepancy between the model and the observed data. Furthermore, the RMSEA of 0.175 exceeds the acceptable limit of 0.08, and the PCLOSE of 0.001 confirms that the model poorly approximates the population covariance matrix.

Collectively, these values indicate substantial misfit even with some favorable incremental fit measures. These suggest that the current model does not adequately represent the relationships among critical thinking, inquiry-based learning environment, metacognitive awareness, and scientific attitudes, highlighting the need for model refinement or the consideration of additional pathways to better explain students' learning processes.

Figure 5 portrays the best-fit model. The model indicates that the exogenous variables, namely, inquiry-based learning environment, metacognitive awareness, and critical thinking, affect scientific attitudes. It further shows that metacognitive awareness directly influences both inquiry-based learning and critical thinking.

The results reveal that metacognitive awareness strongly affects both the inquiry-based learning environment and critical thinking, with path coefficients of 0.80. Meanwhile, metacognitive awareness and the inquiry-based learning environment exhibit weak influence on scientific attitudes, with path coefficients of 0.19. In contrast, critical thinking demonstrates a moderate influence on scientific attitudes, with a path coefficient of 0.45.

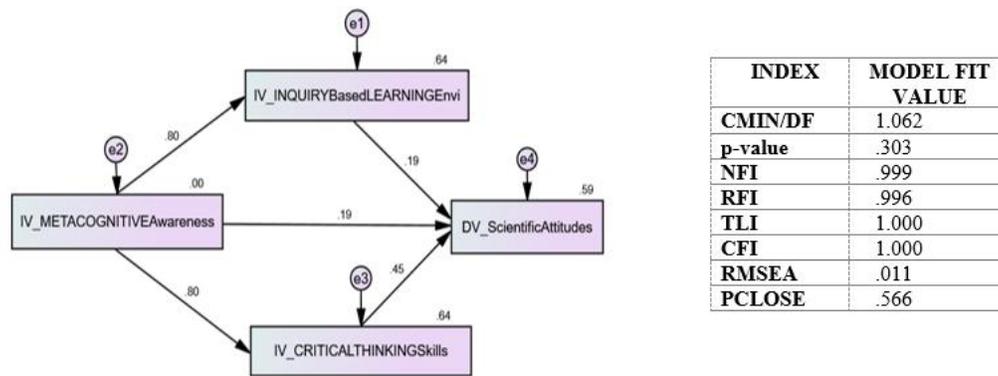


Figure 5. Best Fit Model

The model is considered the best-fit model because the overall fit indices indicate an excellent fit between the hypothesized model and the observed data. The CMIN/DF is 1.062, well below the recommended threshold of 3, and the p-value of 0.303 is not significant, indicating no substantial discrepancy between the model and the observed data. Incremental fit indices are very high: NFI = 0.999, RFI = 0.996, TLI = 1.000, and CFI = 1.000, indicating that the model fits almost perfectly the null model. Furthermore, the RMSEA of 0.011 is far below the 0.08 threshold, and the PCLOSE of 0.566 confirms that the model closely approximates the population covariance matrix.

Overall, this implies that the best-fit model reliably represents the relationships among inquiry-based learning environment, metacognitive awareness, critical thinking, and scientific attitudes. Even though some individual paths show weak relationships, the overall model structure fits the observed data very well, suggesting that the model adequately captures the underlying patterns and interactions among the variables.

This indicates that the model is statistically sound and can be used to explain how these factors collectively influence scientific attitudes. Further, this implies that fostering inquiry-based learning environments and enhancing metacognitive awareness and critical thinking can positively shape their scientific attitudes, even if some influences are stronger than others, ultimately supporting more effective science learning and engagement.

Standardized Direct, Indirect, and Total Effect Estimates on Scientific Attitudes

Table 31 presents the standardized direct, indirect, and total effect estimates of the independent variables on scientific attitudes. The results indicate that the inquiry-based learning environment exerts a direct effect of 0.194 with a significant p-value of 0.004, which is below the conventional threshold of 0.05. Notably, the inquiry-based learning environment shows no indirect effect on scientific attitudes, suggesting that its influence occurs directly without the mediation of other variables. This highlights that inquiry-based learning environments directly and positively shape students' scientific attitudes.

Similarly, metacognitive awareness demonstrates both direct and indirect effects on scientific attitudes. The direct effect is 0.191 (p=0.011), while the indirect effect through critical thinking is 0.517 (p=0.003), yielding a statistically significant total effect of 0.708. These findings underscore the pivotal role of critical thinking as a mediator, indicating that metacognitive awareness strengthens

scientific attitudes both directly and indirectly by fostering critical reasoning skills.

Table 31. *Standardized Direct, Indirect, and Total Effect Estimates on Scientific Attitudes*

<i>Independent Variables</i>	<i>Direct Effect</i>	<i>P</i>	<i>Indirect Effect</i>	<i>P</i>	<i>Total Effect</i>	<i>p</i>
Inquiry-based Learning	.194	.004	.000	-	.194	.004
Metacognitive Awareness	.191	.011	.517	.003	.708	.003
Critical Thinking Skills	.452	.005	.000	-	.452	.005

Additionally, critical thinking exhibits a strong direct effect of 0.452 with a significant p-value of 0.005, but no indirect effect. This confirms that critical thinking independently and robustly contributes to the development of scientific attitudes without requiring mediation.

These findings are consistent to the study of Haynes et al. (2023) emphasized that inquiry-based learning positively influences students' scientific attitudes, particularly in shaping their engagement and enjoyment in science learning. Tarwiyani and Mahanal (2020) further highlighted that inquiry-based environments significantly enhance students' scientific attitudes. Thus, creating inquiry-focused learning experiences is essential for fostering positive scientific dispositions.

In parallel, the results corroborate the findings of Akpur (2025), demonstrating that metacognitive awareness enhances scientific attitudes through the development of critical thinking. Adiansyah et al. (2021) similarly reported that students who are more self-aware in their learning exhibit stronger scientific attitudes, while Al-Balushi et al. (2022) emphasized that high self-regulation skill contribute to improved academic performance and scientific attitudes. Therefore, metacognitive awareness significantly influences students' scientific attitudes, especially when coupled with strong critical thinking abilities.

Furthermore, the findings align with Sekarintyas et al. (2024), indicating that critical thinking directly promotes positive scientific attitudes. Gangrade (2024) also noted that students with high curiosity and evidence-based reasoning, which are the core components of critical thinking, demonstrate enhanced scientific dispositions. Collectively, these studies reinforce that critical thinking is a key determinant of students' scientific attitudes.

Overall, the results suggest that fostering inquiry-based learning environments, promoting metacognitive awareness, and developing critical thinking skills are essential strategies for cultivating students' scientific attitudes. Educators are encouraged to design learning experiences that engage students in inquiry, facilitate reflection on cognitive processes, and nurture critical reasoning, thereby supporting more effective, meaningful, and enduring science learning.

Conclusions

These conclusions were drawn based on the findings above. The students often exhibit scientific attitudes in their learning. This implies that students generally demonstrate curiosity, receptiveness to evidence, and a willingness to engage in scientific inquiry, which are essential dispositions for fostering more profound understanding and sustaining long-term interest in science. The students often engage in an inquiry-based learning environment. This suggests that they actively participate in exploratory and problem-solving activities, fostering critical thinking, independent learning, and a deeper understanding of scientific concepts. The students often demonstrate metacognitive awareness. This indicates that they can plan, monitor, and evaluate their own learning processes, which is vital for developing self-regulated learning and achieving sustained academic growth. The students often display critical thinking. This denotes their ability to analyze information, evaluate evidence, and apply logical reasoning, which are essential competencies for effective problem-solving and meaningful engagement in science learning.

Significant relationships were established among the variables examined in the study. Specifically, the inquiry-based learning environment, metacognitive awareness, and critical thinking were each found to be significantly related to students' scientific attitudes. Likewise, significant relationships were observed among the inquiry-based learning environment and critical thinking, the inquiry-based learning environment and metacognitive awareness, and metacognitive awareness. These findings imply that the development of one construct positively influences the others, highlighting the interconnected nature of learning environments, cognitive processes, and dispositions in shaping students' scientific attitudes. The results further reveal that inquiry-based learning environment, metacognitive awareness, and critical thinking are significant predictors of students' scientific attitudes. This underscores the importance of fostering active and inquiry-driven classrooms, enhancing students' awareness of their own thinking processes, and cultivating critical thinking skills. This finding implies that deliberately integrating these elements into science instruction can effectively strengthen students' scientific attitudes, thereby promoting deeper engagement and sustained interest in scientific learning. The model presented in Figure 10 emerged as the best-fitting, satisfying all statistical criteria for an excellent fit. The model highlights the pivotal role of metacognitive awareness, which strongly influences both inquiry-based learning and critical thinking, while critical thinking, in turn, moderately shapes students' scientific attitudes. Although inquiry-based learning and metacognitive awareness have only weak direct effects on scientific attitudes, the model's overall structure shows that these variables are deeply interconnected. This underscores the importance of fostering inquiry-based learning environments, enhancing metacognitive awareness, and cultivating critical thinking as crucial pathways for strengthening students' scientific attitudes and promoting meaningful science learning.

References

- Abdelrahman, R. M., (2020). Metacognitive Awareness and Academic Motivation and Their Impact on Academic Achievement of Ajman University Students. *Heliyon*, 6(9), 41-92. <https://doi.org/10.1016/j.heliyon.2020.e04192>
- Acarli, D. S., & Dervisoglu, S., (2021). Effect of Inquiry-Based Biology Laboratory Applications on Scientific Process Skills, Attitude, Self-Efficacy and Self-Confidence. *MIER Journal of Educational Studies, Trends and Practices*, 15-29. <https://doi.org/10.52634/MIER/2021/V11/I1/1751>
- Adarlo, G., De Leon, M., & Favis, A. M., (2022). Exploring Students' Attitudes Toward Science and Course Engagement as Predictors of Science Literacy. *Journal of Systemics, Cybernetics and Informatics*, 20(4), 8-14. <https://doi.org/10.54808/JSCI.20.04.8>
- Aggarwal, R., & Ranganathan, P., (2019). Study Designs: Descriptive Studies. *Perspectives in Clinical Research*, 10(1), 34–36. https://doi.org/10.4103/picr.PICR_154_18
- Agustina, L., Sari, D. P., & Yuliani, H., (2024). Students' Creative Thinking Ability on Problems of Mathematics Literacy. *Journal of Higher Education Theory and Practice*, 24(1). <https://doi.org/10.33423/jhetp.v24i1.6760>
- Akcaoglu, M. O., Eskici, M., & Gokbulut, B., (2023). The Mediating Role of Metacognitive Awareness in The Relationship Between Critical Thinking and Self-Regulation. *Thinking Skills and Creativity*, 47, 101187. <https://doi.org/10.1016/j.tsc.2022.101187>
- Akmam, A., Afrizon, R., Koto, I., Setiawan, D., Hidayat, R., & Novitra, F., (2024). Integration of Cognitive Conflict in Generative Learning Model to Enhancing Students' Creative Thinking Skills. *Eurasia Journal Of Mathematics, Science and Technology Education*, 20(9), em2504-em2504. <https://doi.org/10.29333/ejmste/15026>
- Akpur, U. (2024). Metacognitive Awareness and Academic Achievement: A Meta-Analysis Study. *Elektronik Sosial Bilimler Dergisi*. <https://doi.org/10.17755/esosder.1433740>
- AlAli, R., & Al-Barakat, A. (2024). Young Children's Attitudes Toward Science Learning in Early Learning Grades. *Emerald Insight*. Retrieved from <https://www.emerald.com/insight/2046-3162.htm>
- Alawiah, T., Maksum, A., & Madani, F., (2024). Inquiry-Based Learning Improving Critical Thinking Ability In View Of Elementary School Students' Learning Motivation. *Jurnal Elementaria Edukasia*, 7(3), 2985-2999. <https://doi.org/10.31949/jee.v7i3.9750>
- Al-Balushi, S. M., Al-Harthy, I. S., Almehrizi, R. S., Ambusiadi, A. K., Al-Saadi, K. K., Al-Aghbari, M. S., Al-Balushi, M., & Al-Balushi, K. A., (2022). Metacognitive Awareness Perceptions Of Students With High And Low Scores On TIMSS-Like Science Tests. *International Journal of Cognitive Research in Science, Engineering and Education*, 10(3), 73–82. <https://doi.org/10.23947/2334-8496-2022-10-3-73-82>
- Al-Hanifah, J. A., Cholily, Y. M., & Ummah, S. K., (2023). Analysis Of Students' Analytical Thinking Ability And Mathematical Communication Using Online Group Investigation Learning Model. *Mathematics Education Journal*, 7(1), 100-113. <https://doi.org/10.22219/mej.v7i1.23342>
- Alimbaev, M. (2023). Student Autonomy and Self-Directed Learning in English Classrooms. *Renaissance in the Paradigm of Educational and Technological Innovations in the 21st Century*. <https://doi.org/10.47689/xxia-ttipr-voll-iss1-pp320-323>
- Alsaleh, N. J. (2020). Teaching Critical Thinking Skills: Literature Review. *The Turkish Online Journal of Educational Technology*, 19(1), 21–30. Retrieved from <https://files.eric.ed.gov/fulltext/EJ1239945.pdf>
- Alsharif, H., & Symons, J. (2020). Open-Mindedness as a Corrective Virtue. *Philosophy*, 96(1), 73-97. <https://doi.org/10.1017/S0031819120000352>
- Antonio, R. P., & Prudente, M. S. (2024). Effects of inquiry-based approaches on students' higher-order thinking skills in science: A meta-analysis. *International Journal of Education in Mathematics, Science and Technology*, 12(1), 251–281. <https://doi.org/10.46328/ijemst.3216>
- Arifianti, D., & Baidawi, M. (2024). Improving Students' Creative Thinking Skills in Mathematics Through Solving Open-Ended Problems. *Jurnal Multidisiplin Ibrahimy*, 2(1), 113-120. <https://doi.org/10.35316/jummy.v2i1.5551>
- Astalini, A., Darmaji, D., Pathoni, H., Kurniawan, W., Jufrida, J., Dwi Agus Kurniawan, & R. Perdan., (2019). Motivation and Attitude of Students on Physics Subject in The Middle School in Indonesia. *International Education Studies*, 12(9), 15-24. <https://doi.org/10.5539/ies.v12n9p15>
- Azevedo, R. (2019). Developing Critical Thinking Skills in K-12 Schools. In R. J.ternberg & R.
- Babaylo, P. M. A. (2023). Science-Related Attitudes and Academic Achievements of Students with Varied Learning Styles. *Journal of Science and Technology Education*, 3(1). <https://nostonline.org/science-related-attitudes-and-academic-achievements-of-students-with-varied-learning-styles/>
- Bellaera, L., Weinstein-Jones, Y., Ilie, S., & Baker, S. T., (2021). Critical Thinking in Practice: The Priorities And Practices of

- Instructors Teaching in Higher Education. *Thinking Skills and Creativity*, 42, 100856. <https://doi.org/10.1016/j.tsc.2021.100856>
- Berkson, G., & Gijbels, D. (2020). Translating Knowledge into Practice: An Overview. *Journal of Applied Research in Higher Education*, 12(3), 483-495. <https://doi.org/10.1108/JARHE-02-2019-0035>
- Bernardo, A. B. I., Salanga, M. G. C., & Aguas, K. M. C., (2008). Filipino Adolescent Students' Conceptions Of Learning Goals. What the West can learn from the East: Asian perspectives on the psychology of learning and motivation (pp. 169–190). Information Age Publishing.
- Bhandari, P. (2021). Ethical Considerations In Research: Types & Examples. Retrieved from <https://www.scribbr.com>
- Bineth, A. (2021). Towards A Sociology Of Curiosity: Theoretical And Empirical Consideration Of The Epistemic Drive Notion. *Theory and Society*, 1-26. <https://doi.org/10.1007/S11186-021-09464-Y>
- Bitzenbauer, P. (2021). Development of a Test Instrument to Investigate Secondary School Students' Declarative Knowledge of Quantum Optics. *European Journal of Science and Mathematics Education*, 9(3), 57-79. <https://doi.org/10.30935/SCIMATH/10946>
- Błaszczak, A. (2022). Actively Open-Minded Thinking: Introduction and an Attempt to Describe the Idea Behind. *Annales Universitatis Mariae Curie-Sklodowska*, 35(3), 23-41. <https://doi.org/10.17951/j.2022.35.3.23-41>
- Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R., (1956). *Taxonomy of Educational Objectives: The Cognitive Domain*. David McKay Company.
- Boukayoua, Z., Kaddari, F., & Bennis, N., (2021). Students' Interest in Science Learning and Measurement Practices: Questions for Research in The Moroccan School Context. *SHS Web of Conferences*, 119, 05006. <https://doi.org/10.1051/shsconf/202111905006>
- Braithwaite, D. W., & Sprague, L. (2021). Conceptual Knowledge, Procedural Knowledge, and Metacognition in Routine and Nonroutine Problem Solving. *Cognitive Science*, 45(10). <https://doi.org/10.1111/COGS.13048>
- Butvilas, T., Zilinskiene, D., Bubnys, R., Colomer, J., Cañabate, D., & Masoodi, M., (2023). Metacognitive Awareness, Knowledge and Regulation of Cognition Factors Among Lithuanian University Students. *Journal of Applied Research in Higher Education*. <https://doi.org/10.1108/jarhe-02-2023-0069>
- Cacciattolo, M. (2015). Ethical Considerations in Research. In *The Praxis of English Language Teaching and Learning*. 61–79. https://doi.org/10.1007/978-94-6300-112-0_4
- Cakıcı, D. (2018). Metacognitive awareness and critical thinking abilities of pre-service EFL teachers. *Journal of Education and Learning*, 7(5), 116–126. <https://doi.org/10.5539/jel.v7n5p116>
- Capiral, C. I. S. (2022). Scientific Attitude Inventory of Junior High School Students During Pandemic. *International Journal of Multidisciplinary: Applied Business and Education Research*, 3(11). <https://doi.org/10.11594/ijmaber.03.11.03>
- Casa-Coila, M. D., Mamani-Vilca, P. S., Pari-Achata, D., Pacori-Zapana, E., Perez-Argollo, K., & Paredes-Aliaga, J. S., (2024). Inquiry-Based Learning and Collaborative Work in Undergraduate Students. *Journal of Law and Sustainable Development*, 12(3), 34-40. <https://doi.org/10.55908/sdgs.v12i3.3440>
- Cekule, L., & Cekuls, A. (2022). Understanding the Potential of Information in Decision Making. *Proceedings of the 19th International Scientific Conference*. <https://doi.org/10.35603/sws.iscss.2022/s08.090>
- Chali, M. T., Eshete, S. K., & Debela, K. L., (2022). Learning How Research Design Methods Work: A Review of Creswell's Research Design: Qualitative, Quantitative and Mixed Methods Approaches. *The Qualitative Report*, 27(12), 2956-2960. <https://doi.org/10.46743/2160-3715/2022.5901>
- Chan, J. W. W., & Pow, J. W. C. (2020). The Role of Social Annotation in Facilitating Collaborative Inquiry-Based Learning. *Computers & Education*, 147. <https://doi.org/10.1016/j.compedu.2019.103787>
- Charles, E. S., Lenton, K., Adams, R., Dugdale, M., Hughes, S., Laroche, K., Cormier, C., Turcotte, V., & Zhang, C., (2022). Successfully Implementing Inquiry-Based Labs: A Case Study for a College Waves and Modern Physics Course. *Proceedings of SPIE*. <https://doi.org/10.1117/12.2632373>
- Chaudhari, R., & Deshpande, K. (2023). ML Based Comprehensive Application to Enhance Soft Skills. *Proceedings of the 2023 International Conference on Emerging Trends in Engineering and Technology*, 1-6. <https://doi.org/10.1109/ICETET-SIP58143.2023.10151569>
- Chen, C. (2022). Curiosity. *International Surgery*, 195-195. <https://doi.org/10.9738/0020-8868-99.3.195>
- Chen, R. H. (2021). Fostering Students' Workplace Communicative Competence and Collaborative Mindset through an Inquiry-Based Learning Design. *Education Sciences*, 11(1), 17. <https://doi.org/10.3390/educsci11010017>
- Chepkirui, J., & Huang, W. (2021). A Path Analysis Model Examining Self-Concept and Motivation Pertinent to Undergraduate Academic Performance: A Case of Kenyan Public Universities. *Educational Research and Reviews*, 16(3), 64-71.

<https://doi.org/10.5897/ERR2021.4123>

Chheun, S., & Kong, S. O. (2023). Implementing Scientific Method to Strengthen the Student's Scientific Attitude: A Study on Biology Subject. *INSECTA*. <https://doi.org/10.21154/insecta.v4i2.7563>

Chong, S., & Lu, T. (2019). Early Childhood Teachers' Perception of the Professional Self And in Relation to the Early Childhood Communities. *Australian Journal of Teacher Education*, 44(7), 53-67. <https://doi.org/10.14221/ajte.2019v44n7.5>

Chumdari, C., Widiyanto Atmojo, I. R., Ardiansyah, R., & Shintawati, A., (2023). The Effect of Metacognitive Awareness on the Critical Thinking Skills of Elementary School Prospective Teachers. *AL-ISHLAH Jurnal Pendidikan*, 15(4), 4527. <https://doi.org/10.35445/alishlah.v15i4.4527>

Constantine, E. A., & Lay, Y. F. (2013). Attitudes towards Science and Metacognitive Awareness: Impact on Students' Science Achievement. 5th International Conference on Science and Mathematics Education, SEAMEO RECSAM, Penang, Malaysia. Retrieved from https://www.researchgate.net/publication/311948550_Attitudes_towards_Science_and_Metacognitive_Awareness_Impact_on_Students'_Science_Achievement

Crossman, J. (2023). Superstitions and Rationality. In *Palgrave Studies in Workplace Spirituality and Fulfillment* (pp. 103-123). Palgrave Macmillan. https://doi.org/10.1007/978-3-031-59020-7_6

Curtain, S. (2022). How Can I Reimagine My Practice So That I Teach 'Big Ideas' Rather Than Subject-Specific Content?. In *Innovative Teaching in Higher Education*, 39-49. https://doi.org/10.1007/978-981-99-5099-7_4

Corredor, B. Y. A., González, R., Montenegro, C. E., & Sánchez, C. A. (2023). Didactics to Enhance Observation, in *Educational Contexts*. 114-121. doi: 10.1007/978-3-031-44131-8_12

DeCaro, M. S., & Rittle-Johnson, B. (2019). Examining the Roles of Prior Knowledge And Conceptual Understanding in The Effects of Self-Explanation on Procedural Knowledge. *Cognitive Psychology*, 113, 101-224. <https://doi.org/10.1016/j.cogpsych.2019.101224>

Dignath, C., van Ewijk, R., Perels, F., & Fabriz, S., (2023). Let Learners Monitor the Learning Content and Their Learning Behavior! A Meta-analysis on the Effectiveness of Tools to Foster Monitoring. *Educational Psychology Review*, 35(2) doi: 10.1007/s10648-023-09718-4

Di Vincenzo, F., Mascia, D., Bjork, J., & Magnusson, M., (2021). Attention to Ideas! Exploring Idea Survival in Internal Crowdsourcing. *European Journal of Innovation Management*, 24(2), 213-234. <https://doi.org/10.1108/EJIM-03-2019-0073>

Divrik, R., Pilten, P., & Tas, A. M., (2020). Effect of Inquiry-Based Learning Method Supported by Metacognitive Strategies on Fourth-Grade Students' Problem-Solving and Problem-Posing Skills: A Mixed Methods Research. *International Electronic Journal of Elementary Education*, 13(2), 287-308. <https://doi.org/10.26822/iejee.2021.191>

Duran, M., & Dokme, I., (2016). The Effect of Inquiry-Based Learning Approach on Students' Critical Thinking Skills. *EURASIA Journal of Mathematics, Science and Technology Education*, 12(12), 2887-2908. <https://doi.org/10.12973/eurasia.2016.02311a>

Durukan, N., Kızıkan, O., & Bektaş, O., (2022). Metacognition Enhancing Strategies in Science Classrooms: Science Teachers' Practices. *Inquiry in Education*, 14(1), Article 5. Retrieved from <https://digitalcommons.nl.edu/ie/vol14/iss1/5>

Edwards, A. A., Steacy, L. M., Siegelman, N., Rigobon, V. M., Kearns, D. M., Rueckl, J. G., & Compton, D. L., (2022). Unpacking the Unique Relationship Between Set for Variability and Word Reading Development: Examining Word- And Child-Level Predictors of Performance. *Journal of Educational Psychology*, 114(6), 1242-1256. <https://doi.org/10.1037/edu0000696>

Esteban, A. M. Jr., Darmuki, A., & Esteban, A., (2023). The Effect of Collaboration Inquiry Problem Based Learning Model on 4C Skills. *Kredo: Jurnal Ilmiah Bahasa dan Sastra*. <https://doi.org/10.24176/kredo.v7i1.9838>

Eymur, G., & Geban, O. (2011). An Investigation of the Relationship between Motivation and Academic Achievement of Pre-Service Chemistry Teachers. *Eğitim ve Bilim*, 36(161). Retrieved from https://www.researchgate.net/publication/270896533_An_Investigation_of_the_Relationship_between_Motivation_and_Academic_Achievement_of_Pre-service_Chemistry_Teachers

Fahmidani, Y., & Rohaeti, E. (2020). Attitude Toward Chemistry: Student's Perception Based on Learning Experience. *Journal of Physics: Conference Series*, 1440(1), 12-16. <https://doi.org/10.1088/1742-6596/1440/1/012016>

Fathayati, S., Isnaeni, W., & Marianti, A., (2021). Scientific Attitude Assessment Instruments Using Self-Assessment in Project-Based Learning Development. *Journal of Innovative Science Education*. doi: 10.15294/jise.v10i1.49985

Fatkhrayah, R. Y. (2019). Inquiry-Based Learning: An Attempt to Enhance Students' Speaking Performance. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, 4(7), 912-922. <https://doi.org/10.17977/JPTPP.V4I7.12633>

Fatonah, S., Prasetyo, Z. K., Utami, A. D., Chasanah, U., Lusiana, L., & Siregar, V. V., (2024). Scientific Attitude and Its Effect on Students' Productivity. *Jurnal Pendidikan IPA Indonesia*, 12(4). <https://doi.org/10.15294/jpii.v12i4.47727>

- Fisher, M. (2023). Exploring Factors Affecting Scientific Attitude in Secondary School Students: A Comprehensive Analysis. *Research Highlights in Language and Linguistics Education*, 38-53. <https://doi.org/10.9734/bpi/rhlle/v7/5712a>
- Flavell, J. H. (1979). Metacognition and Cognitive Monitoring: A New Area of Cognitive–developmental Inquiry. *American Psychologist*, 34(10), 906–911. <https://doi.org/10.1037/0003-066X.34.10.906>
- Francisco, F., & Gonçalves-Sá, J. (2019). A Little Knowledge is a Dangerous Thing: Excess Confidence Explains Negative Attitudes towards Science. *Social Science Research Network*. <https://doi.org/10.2139/SSRN.3360734>
- Fregonese, F. (2018). Community Involvement in Biomedical Research Conducted in The Global Health Context: What can be done to make it really matter?. *BMC Medical Ethics*, 19(1), 44. <https://doi.org/10.1186/s12910-018-0283-4>
- Gangrade, R. M. J. (2024). The Influence of Scientific Attitude on Academic Achievement among Secondary School Students. *International Journal for Multidisciplinary Research*, 6(3). <https://doi.org/10.36948/ijfmr.2024.v06i03.20725>
- Garcia-Carmona, A. (2023). Scientific Thinking and Critical Thinking in Science Education: Two Distinct but Symbiotically Related Intellectual Processes. *Science & Education*. <https://doi.org/10.1007/s11191-023-00460-5>
- Garzon, J. R. (2023). Metacognitive Inquiry Via Reflective Tasking Methodology. *International Journal of Research and Innovation in Social Science*, 7(1), Article 1136. <https://dx.doi.org/10.47772/IJRISS.2023.7011136>
- Gaunkar, N. P., & Mina, M. (2020). A Perspective on Students' Autonomy in Learning and Engaging in an Inquiry-Based Learning Environment. Paper presented at the 2020 ASEE Virtual Annual Conference Content Access. <https://doi.org/10.18260/1-2--34032>
- Gkagkas, V., & Hatzikraniotis, E. (2024). Exploring the Development of Questioning Inquiry Skill in Secondary School Students Via Physics Inquiry-Based Learning Experiments. Paper presented at the 13th International Conference on New Perspectives in Science Education, Florence, Italy. <https://doi.org/10.13140/RG.2.2.38179.76595>
- Gladovic, C., McDonald, B., & McDonald, J., (2023). How Can Learners Practice Evaluative Judgement Using Qualitative Self-Assessment?. *Assessment & Evaluation in Higher Education*. <https://doi.org/10.1080/02602938.2023.2291341>
- Gordon, B. G. (2020). Vulnerability in Research: Basic Ethical Concepts and General Approach to Review. *Ochsner Journal*, 20(34–38). <https://doi.org/10.31486/toj.19.0079>
- Gormally, C., Brickman, P., Hallar, B., & Armstrong, N., (2009). Effects of Inquiry-Based Learning on Students' Science Literacy Skills and Confidence. *International Journal for the Scholarship of Teaching and Learning*, 3(2). <https://doi.org/10.20429/ijstol.2009.030216>
- Goupil, L., & Proust, J. (2022). Curiosity as a Metacognitive Feeling. *Social Science Research Network*, 23(1). <https://doi.org/10.2139/ssrn.4141925>
- Grant, S. C. (2021). Informed Consent—We Can and Should Do Better. *JAMA Network Open*, 4(4), e2110848. <https://doi.org/10.1001/jamanetworkopen.2021.10848>
- Guerrero, J. S., & Bautista, R. G. (2023). Inquiry-Based Teaching in Secondary Science. *International Journal of Social Sciences and Humanities*, 8(2), 146-154. <https://doi.org/10.58885/ijssh.v08i2.146.jg>
- Gutierrez de Blume, A. P., Wang, Y., Du, H., & Montoya Londoño, D. M., (2024). An Investigation of Subjective Metacognitive Awareness and Objective Absolute Monitoring Accuracy among Undergraduate Students from China, Colombia, Spain, And The U.S.: The Role Of Culture. *Revista CES Psicología*. <https://doi.org/10.21615/cesp.7303>
- Halini, H., Zubaidah, R., Pasaribu, R. L., Mirza, A., & Afriansyah, E. A., (2023). Students' Scientific Attitudes and Creative Thinking Skills. *Mosharafa: Jurnal Pendidikan Matematika*, 12(2), 315-326. <https://doi.org/10.31980/mosharafa.v12i2.2326>
- Hankin, D. G., Mohr, M. S., & Newman, K. B., (2019). Stratified Sampling in Ecological and Natural Resource Sciences. in *Sampling Theory: For the Ecological and Natural Resource Sciences*, 68-91. Oxford University Press. <https://doi.org/10.1093/oso/9780198815792.003.0005>
- Hannan, C. E., (2019). Very Superstitious: The Relationship between Desperation and Superstitious Behavior. *Murray State Theses and Dissertations*, 145. Retrieved from <https://digitalcommons.murraystate.edu/etd/145>
- Hartelt, T., & Martens, H., (2024). Self-Regulatory and Metacognitive Instruction regarding Student Conceptions: Influence on Students' Self-Efficacy And Cognitive Load. *Frontiers in Psychology*, 15. <https://doi.org/10.3389/fpsyg.2024.1450947>
- Hassan, S., Venkateswaran, S. P., Agarwal, P., Sulaiman, A. R., & Burud, I. A. S., (2022). Metacognitive Awareness and its Relation to Students' Academic Achievement: Time to Ponder its Implication in Delivery of the Curriculum. *Research Square*. <https://doi.org/10.21203/rs.3.rs-1266966/v1>
- Heinbach, D. (2022). Rationality. *DOCA*. <https://doi.org/10.34778/5t>
- Heinonen, K., & Gruen, T. (2024). Elevating Conceptual Research: Insights, Approaches, and Support. *AMS Review*, 14(1), 1-6.

<https://doi.org/10.1007/s13162-024-00283-9>

Haynes, M., Brown, A., Nichols, K., & Musofer, R. P. (2023). Measurement of Student Attitudes to Science and Association with Inquiry-based Learning in Regional Schools. *International Journal of Science Education*, 45(8), 593–612. <https://doi.org/10.1080/09500693.2023.2168138>

Hidayat, S., Muhali, M., & Zubaidah, R., (2019). The Effect of The Inquiry Learning Model on Students' Metacognition Awareness. *Lensa: Jurnal Kependidikan Fisika*, 7(2), 31. <https://doi.org/10.33394/j-lkf.v7i2.2049>

Hogan, E. A. (2024). Using Inquiry-Based Learning to Improve Student's Critical Thinking and Problem-Solving Skills in Science . SUNY Brockport, Department of Education and Human Development. Retrieved from <https://soar.suny.edu/handle/20.500.12648/14089>

Holden, T. G., & Yore, L. D. (1996). Relationships among Prior Conceptual Knowledge, Metacognitive Awareness, Metacognitive Self-Management, Cognitive Style, Perception-Judgment Style, Attitude toward School Science, Self-Regulation, and Science Achievement in Grade 6-7 Students. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, St. Louis, MO. Retrieved from <https://files.eric.ed.gov/fulltext/ED395823.pdf>

Hong, J. C., Lin, S. S., & Hwang, M. Y., (2021). Critical Attitude and Ability Associated with Students' Self-Confidence and Attitude toward "Predict-Observe-Explain" Online Science Inquiry Learning. *Computers & Education*, 164, 104172. <https://doi.org/10.1016/j.compedu.2021.104172>

Howell, C. R., Su, W., Nassel, A. F., Agne, A. A., & Cherrington, A. L., (2020). Area-Based Stratified Random Sampling using Geospatial Technology in a Community-Based Survey. *BMC Public Health*, 20, 1678. <https://doi.org/10.1186/s12889-020-09455-2>

Hunaepi, H., Suma, I. K., & Subagia, I. W., (2024). Curiosity in Science Learning: A Systematic Literature Review. *International Journal of Essential Competencies in Education*, 3(1), 77-105. <https://doi.org/10.36312/ijece.v3i1.1918>

Hwang, G. H., Chen, B., Chen, R. S., Wu, T. T., & Lai, Y. L., (2019). Differences between Students' Learning Behaviors and Performances of Adopting A Competitive Game-Based Item Bank Practice Approach for Learning Procedural and Declarative Knowledge. *Interactive Learning Environments*, 27, 740-753. <https://doi.org/10.1080/10494820.2019.1610458>

Ibragimova, E. A., Zhumagulova, M. Sh., & Kheday, N. R., (2024). The Role of Critical Thinking in Forming Students' Research competence. *Pedagogics*, 73(2). <https://doi.org/10.48371/peds.2024.73.2.015>

Ignatova, N., Pranckuniene, E., Strazdiene, N., & Smitiene, G., (2024). Inquiry-based Learning Projects Design for STEAM Education Addressing Sustainability Challenges. In *Advances in Human Services and Public Health*, 285-306. <https://doi.org/10.4018/979-8-3693-2987-0.ch015>

Inayah, N., & Lubab, A. (2023). Enhancing Analytical Thinking Skills and Scientific Attitudes of Prospective Science Teacher Students through Pre-Practicum Virtual Simulation. *EDUSAINS*. <https://doi.org/10.15408/es.v15i2.35431>

Ince, M. (2023). Examining The Role of Motivation, Attitude, and Self-Efficacy Beliefs in Shaping Secondary School Students' Academic Achievement in Science Course. *Sustainability*. <https://doi.org/10.3390/su151511612>

Indrawatiningsih, N., Purwanto, A. R. As'ari, D., Sudirman, & Rahardi, R., (2019). The Ability of High School Students' Critical Thinking in Solving Trigonometric Problems. *Earth and Environmental Science*, 243(1), 12-50. <https://doi.org/10.1088/1755-1315/243/1/012050>

Irfan, M., Khan, S. Z., Hassan, N., Hassan, M., Habib, M., Khan, S., & Khan, H. H., (2021). Role of Project Planning and Project Manager Competencies on Public Sector Project Success. *Sustainability*, 13(3), 14-21. <https://doi.org/10.3390/su13031421>

Islamiah, I., Ade, T., & Mustika, I. (2019). Efforts to Improve the Writing Ability of Text Reports of Observation Results of Students Class. 2(1):22-28. doi: 10.22460/JLER.V2I1.P22-28

Ita, A. J., & Khoiro, U. (2022). Metacognitive Awareness of Students in Animal System Lectures with Portfolio-Based Assignments and Learning Journals. *Bioscientist*. 10(2), 1209-1209. <https://doi.org/10.33394/bioscientist.v10i2.6719>

Ivanova, D. D., & Zhelyazka, R. (2023). Inquiry-Based Learning Approach in Teaching "Phase Transitions" for Experimental Skills Formation in Nearly 16 Years Old Students. <https://doi.org/10.22323/1.427.0256>

Iyer, L. (2019). Critical Thinking and its Importance In Education. *Cognitive, Psychological and Behavioural Perspectives in Education*. Retrieved from https://www.researchgate.net/publication/339433132_Critical_Thinking_and_its_Importance_in_Education

Jagat, L. S., Maulidah, E., Abdillah, F., Sauri, A. S., & Qiptiyah, T. M., (2024). Improving Students' Abilities by Developing an Inquiry Learning Model. *Jurnal Manajemen dan Pendidikan Agama Islam*, 2(1), 275-281. <https://doi.org/10.61132/jmpai.v2i1.482>

Jaleel, S., & Premachandran, P. (2016). A Study on the Metacognitive Awareness of Secondary School Students. *Universal Journal of Educational Research*, 4(1), 165-172. <https://doi.org/10.13189/ujer.2016.040121>

- Jamil, M., & Bibi, T. (2024). Critical Thinking Skills Development among Secondary School Students: An Analysis of Chemistry Textbook Grade X. *Research Journal for Societal Issues*, 16(2), 1-11. <https://doi.org/10.56976/rjsi.v6i2.202>
- Jamir, T. (2023). Integration Of Skills In Higher Education: Its Relevance. *International Journal For Multidisciplinary Research*. <https://doi.org/10.36948/ijfmr.2023.v05i06.8860>
- Jesús, P., & Azevedo, J. (2024). Student Participation: Auspices and Contradictions on an Educational Innovation Context. *Participatory Educational Research*, 11(5), 59-80. <https://doi.org/10.17275/per.24.64.11.5>
- Jia, T., Wang, C., & Sun, L., (2023). Research on Visual Teaching Strategy of Chemical Declarative Knowledge in Middle School. *Advances in Social Sciences Research Journal*, 10(6), 193–200. <https://doi.org/10.14738/assrj.106.14838>
- Jirout, J. (2020). Supporting Early Scientific Thinking through Curiosity. *Frontiers in Psychology*, 11, 1717. <https://doi.org/10.3389/FPSYG.2020.01717>
- Johnson, E. S., Reddy, L. A., & Jones, N. D., (2020). Introduction to the Special Series: Can Direct Observation Systems Lead to Improvements in Teacher Practice and Student Outcomes?. *Journal of Learning Disabilities*, 54(1), 3-5. <https://doi.org/10.1177/0022219420944795>
- Jones, M. G., Chesnutt, K., Ennes, M., Macher, D., & Paechter, M., (2022). Measuring Science Capital, Science Attitudes, and Science Experiences in Elementary and Middle School Students. *Studies in Educational Evaluation*, 74, 101180. <https://doi.org/10.1016/j.stueduc.2022.101180>
- Justina Lantajo. (2022). An Assessment of Science-Related Attitudes among Freshmen Students in a Philippine University. *International Journal of Social Sciences: Current and Future Research Trends*, 14(1), 134–143. Retrieved from https://ijsscfrtjournal.isrra.org/index.php/Social_Science_Journal/article/view/1067
- Kaçar, T., Terzi, R., Arıkan, İ., & Kırıkçı, A. C. (2021). The Effect of Inquiry-Based Learning on Academic Success: A Meta-Analysis Study. *International Journal of Education and Literacy Studies*, 9(2), 15-23. <https://doi.org/10.7575/AIAC.IJELS.V.9N.2P.15>
- Kakalejeik, L., & Pal'ova, D. (2019). Enhancement of Students' Skills Via Project-Based Learning. *Proceedings of the 42nd International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO)*, 661-666. <https://doi.org/10.23919/MIPRO.2019.8756958>
- Kamal, P., & Soleha, M. (2023). Ability to Write Scientific Work for Class XI Students of SMA Negeri 4 Sidenreng Rappang Based on Direct Observation. *Edumaspul : Jurnal Pendidikan*, 7(2). doi: 10.33487/edumaspul.v7i2.7002
- Kane, M. T. (2020). Validating the Interpretations and Uses of Test Scores. *Journal of Educational Measurement*, 57(2), 1-17. <https://doi.org/10.1111/jedm.12218>
- Kaur, N. (2020). Metacognitive Awareness in Lexical Learning among Malaysian Students. *International Journal of English Language and Literature Studies*, 9(3), 161-171. <https://doi.org/10.18488/JOURNAL.23.2020.93.161.171>
- Khan, M., & Siddiqui, M. A. (2020). Examining Scientific Attitude Scales in India: Development and Validation of a New Scale. *Interdisciplinary Journal of Environmental Science Education*, 16(4), e2223. <https://doi.org/10.29333/ijese/8557knowledge, skills, and attitude of Science, Technology, and Society students across programs>
- Klofutar, Š., Jerman, J., and Torkar. (2020). Direct Versus Vicarious Experiences for Developing Children's Skills of Observation in Early Science Education. *International Journal of Early Years Education*, 1-18. doi: 10.1080/09669760.2020.1814214
- Kobylarek, A., Błaszczynski, K., Ślósarz, L., & Madej, M., (2024). Critical Thinking Questionnaire Construction and Application of Critical Thinking Test Tool. *Journal of Educational Research*, 22(1), 35-50. <https://doi.org/10.1234/jeduresearch.2024.12345>
- Kori, K. (2020). Inquiry-Based Learning in Higher Education. In *Handbook of Research on Advancing Teaching and Learning Through Educational Technology*. 59-74. https://doi.org/10.1007/978-981-16-2082-9_4
- Kotsis, K. T. (2024). The Significance of Experiments in Inquiry-based Science Teaching. *European Journal of Education and Pedagogy*, 5(2), 86–92. <https://doi.org/10.24018/ejedu.2024.5.2.815>
- Kovalchuk, I., et al., (2023). Peculiarities of Metacognitive Processes in Students' Learning Activity. *Scientific Notes of the National University "Ostroh Academy"*, 1(17(85)), 193-195. [https://doi.org/10.25264/2519-2558-2023-17\(85\)-193-195](https://doi.org/10.25264/2519-2558-2023-17(85)-193-195)
- Kruse, J. W., et al., (2022). Learning to Learn: Drawing Students' Attention to Ideas About Learning. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, 95(7), 1-7. <https://doi.org/10.1080/00098655.2022.2033670>
- Küçükaydın, M. A. (2021). Examination of Elementary School Students' Scientific Attitudes and Intellectual Risk-Taking Behaviors. *Science Education International*, 32(2), 149-158. <https://doi.org/10.33828/sei.v32.i2.8>
- Kunovich, R. M. (2022). Confidence in Science: Perceptions of Harmful Consequences, Scientific Uncertainty, and the Pursuit Of Self-Interest in Scientific Research. *SAGE Open*, 12(3), 1-13. <https://doi.org/10.1177/23780231221093162>



- Kusuma, A. K., et al., (2021). The Relationship Between Students' Problem Solving Skills and Scientific Attitude with Students' Learning Outcomes on Stoichiometry at Tenth Grade at High School in Boyolali, Central Java, Indonesia. *Journal of Physics: Conference Series*, 1842, 012027. <https://doi.org/10.1088/1742-6596/1842/1/012027>
- Lawrence, F. P., (2023). Correlational Research. *Research Methodology Group, UOPX ResearchCommunity*. Retrieved from <https://www.phoenix.edu/content/dam/edu/research/doc/2023/correlational-research.pdf>
- Le, T. L. (2024). The Role of Critical Thinking in Secondary Education. *Journal of Science*, 53(2), 165-173. <https://doi.org/10.56824/vujs.2024.htkhgd208>
- Leasa, M. (2024). Contribution Of Metacognition Awareness To Critical Thinking Skills With PBL Model And HPC Strategy: A Food Digestion System Study. *Biosfera: Jurnal Pendidikan Biologi*, 29(2), 1-10. <https://doi.org/10.21009/biosferjpb.29921>
- Leekhot, K., Payoukiattikun, W., & Thongsuk, T., (2024). The Results of Inquiry-Based Learning Management on Critical Thinking and Academic Achievement of Grade-8 Students. *Integrated Science Education Journal*, 5(3), 161–167. <https://doi.org/10.37251/isej.v5i3.901>
- Lestari, F. D., Syahbana, A., & Retta, A. M., (2022). Analysis of Students' Concept Understanding Ability through E-Modules On Linear Program Materials. *MEJ (Mathematics Education Journal)*, 6(1), 104-117. <https://doi.org/10.22219/mej.v6i1.19314>
- Li, N. (2023). Research on the Cultivation of Students' Independent Learning Ability. *Adult and Higher Education*, 5, 49-54. <http://dx.doi.org/10.23977/aduhe.2023.051906>
- Li, H., (2021). Confidence Charms: How Superstition Influences Overconfidence Bias in Han and the Qiang Ethnic Minority Chinese. *The Journal of Psychology*, 155(5):473-488. doi: 10.1080/00223980.2021.1902918
- Lower-Hoppe, L. M., Brgoch, S., Chen, Y.-J., & Sutherland, S., (2020). Inquiry-Based Learning in Action: Theory and Practice in Higher Education. In *Transformative Pedagogies in Higher Education* 34-59. <https://doi.org/10.4018/978-1-7998-4360-3.CH003>
- Lu, K., Pang, F., & Shadiev, R. (2021). Understanding the Mediating Effect of Learning Approach Between Learning Factors and Higher Order Thinking Skills in Collaborative Inquiry-Based Learning. *Educational Technology Research and Development*, 69(5), 1-18. <https://doi.org/10.1007/S11423-021-10025-4>
- Makarov, Z., & Bohatyrychuk, D. (2021). Scientific Rationality in an Educational Context: Historical and Philosophical Analysis. <https://doi.org/10.30525/978-9934-26-193-0-20>
- Manishimwe, H., Shivoga, W. A., & Nsengimana, V., (2022). Exploring the Impact of Enquiry-Based Instructional Strategies on Students' Attitudes towards Biology. *International Journal of Learning, Teaching and Educational Research*, 21(12), 20-34. <https://doi.org/10.26803/ijlter.21.12.2>
- Mao, P., Cai, Z., He, J., Chen, X., & Fan, X., (2021). The Relationship between Attitude toward Science and Academic Achievement in Science: A Three-Level Meta-Analysis. *Frontiers in Psychology*, 12 (78), 40-68. <https://doi.org/10.3389/fpsyg.2021.784068>
- McIntyre, L. (2019). The Scientific Attitude: Defending Science from Denial, Fraud, and Pseudoscience. Retrieved from <https://ndpr.nd.edu/reviews/the-scientific-attitude-defending-science-from-denial-fraud-and-pseudoscience/>
- Mihardi, S., Derlina, H. S. Shiddiq, & Sinuraya, J., (2022). Scientific Attitudes in Scientific Online Learning Management for Student Successful Characters. *Advances in Social Sciences Research Journal*, 9(7), 12-769. <https://doi.org/10.14738/assrj.97.12769>
- Mikhail, M., & Moresoli, C. (2024). Inquiry-Based Learning: A Student-Centric Approach to Engaging Students in Sustainability and Life Cycle Thinking. *Proceedings of the Canadian Engineering Education Association*. <https://doi.org/10.24908/pceea.2023.17104>
- Milzow, K., Reinhardt, A., Soderberg, S., & Zinocker, K., (2019). Understanding the Use and Usability of Research Evaluation Studies. *Research Evaluation*, 28(1), 94–107. <https://doi.org/10.1093/reseval/rvy040>
- Mirza, H., Bellalem, F., & Mirza, C., (2023). Ethical Considerations In Qualitative Research: Summary Guidelines For Novice Social Science Researchers. *Social Studies and Research Journal*, 11(1), 441–449.
- Miscevic, N. (2019). The Curiosity of Science. In *Curiosity and Inquiry*, 163-190. https://doi.org/10.1007/978-3-030-57103-0_9
- Mondal, D. (2023). Metacognitive Awareness and Its Relation to Academic Performance Among Learners: A Review Paper. *International Journal of Research and Review*, 10(7), 742–750. <https://doi.org/10.52403/ijrr.20230786>
- Moravcsik, A. (2019). *Transparency in Qualitative Research*. SAGE Publications Ltd. <https://doi.org/10.4135/9781526421036>
- Morisseau, T., Branch, T. Y., & Origgi, G., (2021). Stakes of Knowing the Truth: A Motivational Perspective on the Popularity of a Controversial Scientific Theory. *Frontiers in Psychology*, 12, 708-751. <https://doi.org/10.3389/fpsyg.2021.708751>
- Msaddek, M., & Boudassamout, H. (2023). The Role of Explicit Metacognitive Strategy Intervention in the Promotion of Declarative, Procedural, and Conditional Knowledge of Reading Heuristics Amongst Moroccan EFL University Students. *Journal of Studies in Education*, 13(2), 72-72. <https://doi.org/10.5296/jse.v13i2.20984>

- Muhammad, Q. R., & Inayati, N. (2024). Student Competence in Carrying Out Learning Evaluations in the Era Of Independent Learning. *Globalistik*, 2(1). <https://doi.org/10.59996/globalistik.v2i1.435>
- Murphy, D. H., & Castel, A. D. (2021). Responsible Remembering and Forgetting as Contributors to Memory for Important Information. *Memory & Cognition*, 49, 895–911. <https://doi.org/10.3758/s13421-020-01067-9>
- Mutasam, U., Ibrohim, I., & Susilo, H., (2021). The Impact Of Science Learning Based on Inquiry Integrated with Nature of Science towards Communication and Collaboration Skills. *Conference Proceedings*, 2330(1), 30-64. <https://doi.org/10.1063/5.0043364>
- Naquila, J. C., & Israel, G. F. G. (2022). Attitudes toward Teaching Science and Self-Efficacy as Predictors of Science Teaching Anxiety among Preservice Teachers. *United International Journal for Research & Technology*, 3(8), 115. <https://uijrt.com/paper/attitudes-toward-teaching-science-self-efficacy-predictors-science-teaching>
- Nauzeer, S., & Jaunky, V. C. (2021). A Meta-Analysis of the Combined Effects of Motivation, Learning and Personality Traits on Academic Performance. *Pedagogical Research*, 6(3), 97. <https://doi.org/10.29333/pr/10963>
- Nikolaev, D. (2021). Psychological Concept of the Scientific Rationality Types. Ideal Objects and the Types of Rationality. *Voprosy Filosofii*, 121-131. <https://doi.org/10.21146/0042-8744-2022-10-121-131>
- Nisha, K. & Prema, N. (2022). Level of Scientific Attitude among School Students: A Brief Survey. *Journal of Positive School Psychology*, 6(4), 11583–11586. Retrieved from <http://journalppw.com>
- Norman, E., Pfühl, G., Sæle, R. G., Svartdal, F., Låg, T., & Dahl, T. I., (2019). Metacognition in Psychology. *Review of General Psychology*, 23(4), 403-424. <https://doi.org/10.1177/1089268019883821>
- Nugraha, I., Putri, N. K., & Sholihin, H. (2020). An Analysis of the Relationship Between Students' Scientific Attitude and Students' Learning Style in Junior High School. *Jurnal Sains dan Lingkungan*, 3(3), 185-195. <https://doi.org/10.17509/JSLS.V3I3.22873>
- Nunaki, J. H., Damopolii, I., Kandowanko, N. Y., & Nusantari, E., (2019). The Effectiveness of Inquiry-Based Learning to Train the Students' Metacognitive Skills Based on Gender Differences. *International Journal of Instruction*, 12(2), 505–516. <https://doi.org/10.29333/iji.2019.12232a>
- Nurjanah, Dahlan, J. A., & Wibisono, Y. (2019). Development of Media Model Based on Hands-On Activity to Improve Conceptual Understanding Abilities of Junior High School Students in Bandung District. *Journal of Physics: Conference Series*, 1280, 042001. <https://doi.org/10.1088/1742-6596/1280/4/042001>
- Olschewski, P., Herzmann, P., & Schlüter, K. (2023). Group Work during Inquiry-Based Learning in Biology Teacher Education: A Praxeological Perspective On The Task Of (Collaborative) Protocol Generation. *Education Sciences*, 13(4), 401. <https://doi.org/10.3390/educsci13040401>
- Pambudi, G. D., Yuliati, L., & Mufti, N., (2022). Encouraging Students' Metacognitive Skills through Inquiry Learning. *Inornatus*, 2(1), 43-52. <https://doi.org/10.30862/inornatus.v2i1.272>
- Pasaribu, P. A., Indrawan, R., & Fauzi, A., (2023). Scientific Attitude and Critical Thinking. *Proceedings of the Annual International Conference on Islamic Education and Science*, 2(1), 596. <https://doi.org/10.18326/aicoies.v2i1.596>
- Patankar, S. P., Mandal, S., & Chakraborty, S., (2022). Curiosity as Filling, Compressing, and Reconfiguring Knowledge Networks. Retrieved from <https://typeset.io/pdf/curiosity-as-filling-compressing-and-reconfiguring-knowledge-2ka7q432.pdf>
- Patra, J. P., Dash, D., & Behera, S., (2022). A Novel Approach to Enhance the Employability Skills of Higher Education Students through Teaching Learning Techniques and Tools. In *Teaching and Learning Techniques and Tools*, 122-134. <https://doi.org/10.4018/978-1-6684-4210-4.ch007>
- Payumo, J., Arcanjo, M., Garcia, J., & Mendoza, C., (2021). Mapping Collaborations and Partnerships in SDG Research. *Frontiers in Research Metrics and Analytics*, 5, 612442. <https://doi.org/10.3389/frma.2020.612442>
- Perdana, D., Saragih, S., & Siagian, P. (2022). The Effects of Inquiry Project-Based Learning on the Increasing Student's Science Literacy Skills and Creative Thinking Skills. *Nucleation and Atmospheric Aerosols*. <https://doi.org/10.1063/5.0131311>
- Pereles, A., Roldan, A., & Martinez, J. (2024). The Power of Metacognitive Strategies to Enhance Critical Thinking in Online Learning. *Journal of Technology and Science Education*, 14(3), 831-843. <https://doi.org/10.3926/jotse.2721>
- Piaget, J. (1964). Cognitive Development in Children: Development and Learning. *Journal of Research in Science Teaching*, 2, 176-186. <http://dx.doi.org/10.1002/tea.3660020306>
- Pimentel, D. R. (2024). Learning to Evaluate Sources of Science Misinformation on the Internet: Assessing Students' Scientific Online Reasoning. *Journal of Research in Science Teaching*. <https://doi.org/10.1002/tea.21974>
- Popper, K. (1935). *The Logic of Scientific Discovery*. Springer. Retrieved from <https://psycnet.apa.org/record/1935-02071-000>
- Pramesti, F. D., Firdaus, I., & Ningrum, M. A. (2023). The Analysis of Metacognitive Awareness of the Students' Writing Competence.

- Language and Education Journal, 8(2), 118-127. <https://doi.org/10.52237/lej.v8i2.485>
- Pratt, B., Wild, V., Barasa, E., Kamuya, D., Gilson, L., Hendl, T., & Molyneux, S. (2020). Justice: A Key Consideration in Health Policy and Systems Research Ethics. *BMJ Global Health*, 5, e001942. <https://doi.org/10.1136/bmjgh-2019-001942>
- Probine, S., Perry, J., Alderson, J. M., Heta-Lensen, Y., Burke, R., & McAlevey, F. (2024). Inquiry-Based Project Learning as an Approach to Foster Wellbeing, Sustained Focus, and Bi-Cultural Practice in Early Childhood Education. *Australasian Journal of Early Childhood*, 49(1), 49-62. <https://doi.org/10.1177/18369391231212685>
- Puadah, P. F., Mahmudi, A., & Wahyuningrum, E. (2022). Metacognitive Ability of Junior High School Special Intelligent Students in Solving Mathematical Problems. *The Journal of Analysis*, 8(1), 67-80. <https://doi.org/10.15575/ja.v8i1.15934>
- Pursitasari, I. D., Mulyani, S., & Lestari, W. (2023). Critical Thinking Skills and Student Scientific Attitudes in IPA Learning During The Covid-19 Pandemic. *AIP Conference Proceedings*, 2751, 100006. <https://doi.org/10.1063/5.0143301>
- Putra, E., Sujana, A., & Anggraeni, D. (2021). How Can Scientific Approach Enhancing Student's Curiosity and Learning Outcomes in Science Learning?. In *Proceedings of the 1st International Conference on Research and Education in Science, Technology, Engineering, and Mathematics*. 138-144. <https://doi.org/10.2991/ASSEHR.K.210326.019>
- Qablan, A., Al-Momani, I., Al-Momani, M., & Al-Shara, I. (2024). Inquiry-Based Learning. In *Advances in Educational Technologies and Instructional Design Book*, 1-12. <https://doi.org/10.4018/979-8-3693-0880-6.ch001>
- Ragland, E., & Karcher, E. (2023). The Implementation of Inquiry-Based Learning Activities in an Introductory Animal Science Course. *NACTA Journal*, 66(1). <https://doi.org/10.56103/nactaj.v66i1.66>
- Rahmadiani, R., Lestari, N. A., & Kurniawan, D. A. (2024). Concept Understanding Students on the Two-Variables Linear Equation System Material in Terms of Mathematics Ability. *Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram*. <https://doi.org/10.33394/j-ps.v12i1.10532>
- Rahmi, Y. L., Abdullah, A. G., & Sujana, A. (2019). Enhancing Students' Critical Thinking Skills through Inquiry-Based Learning Model. *Journal of Physics: Conference Series*, 1317, 012193. <https://doi.org/10.1088/1742-6596/1317/1/012193>
- Rannastu-Avalos, M., Maeots, M., & Siiman, L. A. (2023). Developing Collaborative Problem-Solving Skills through Inquiry-Based Learning. *Eesti Haridusteaduste Ajakiri. Estonian Journal of Education*, 11(2), 196-222. <https://doi.org/10.12697/eha.2023.11.2.08>
- Rebucas, E., & Dales, Z. (2022). A Structural Equation Model on Students' Performance in Science Of Grade 9 Learners In Davao De Oro Division. *International Journal of Scientific Research in Multidisciplinary Studies*, 8(5), 116. <https://doi.org/10.26438/ijsrms/v8i5.116>
- Reed, D. E., Kaplita, E. C., McKenzie, D. A., & Jones, R. A. (2022). Student Experiences and Changing Science Interest When Transitioning from K-12 to College. *Education Sciences*, 12(7), 496. <https://doi.org/10.3390/educsci12070496>
- Reese, S. (2022). Writing the Conceptual Article: A Practical Guide. *Digital Journalism*. <https://doi.org/10.1080/21670811.2021.2009353>
- Reinhardt, J. (2019). *Gameful Second and Foreign Language Teaching and Learning: Theory, Research, And Practice*. Springer. <https://doi.org/10.1007/978-3-030-04729-0>
- Rinaldi, R. (2022). Metacognitive Awareness in Students. *Jurnal Neo Konseling*, 4(4), 15-15. <https://doi.org/10.24036/00692kons2022>
- Rivas, S. F., Saiz, C., & Ossa, C. (2022) Metacognitive Strategies and Development of Critical Thinking in Higher Education. *Frontier Psychology* 13, 913219. doi: 10.3389/fpsyg.2022.913219
- Rizki, M. I., Lingga, H. N., Intannia, D., Rahmatullah, S. W., Putra, A. M. P., & Silviana, M. (2024). The Effect of Inquiry-Based Learning on Pharmacist Students. *Vidya Karya*, 39(1), 1-1. <https://doi.org/10.20527/jvk.v39i1.18399>
- Rodriguez Duque, S., Tal, E., & Barbic, S. P. (2024). The Role of Ethical and Social Values in Psychosocial Measurement. *Measurement*, 113, 113993. <https://doi.org/10.1016/j.measurement.2023.113993>
- Romanov, P. A. (2021). Rationality as Meta-Thinking. *Bulletin of Vyatka State University*, 33-40. <https://doi.org/10.25730/vsu.7606.21.031>
- Rumanová, L., Vallo, D., & Laššová, K. (2020). Students' Ability to Solve Geometry Problems with Emphasis on Interdisciplinary Relations. *TEM Journal*, 1755-1759. <https://doi.org/10.18421/TEM94-57>
- Safitri, M., Suryani, N., Asrowi, & Sukarmin. (2024). Validity Of Metacognitive Awareness Inventory as a Measuring Tool for Metacognitive Ability in Mathematics Problem Solving. *Journal of Law and Sustainable Development*. <https://doi.org/10.55908/sdgs.v12i1.2246>
- Şahintepe, S., Erkol, M., & Aydoğdu, B. (2020). The Impact of Inquiry-Based Learning Approach on Secondary School Students' Science Process Skills. *Open Journal for Educational Research*, 4(2), 117-142. <https://doi.org/10.32591/coas.ojer.0402.04117s>

- Saks, K., Ilves, H., & Noppel, A. (2021). The Impact of Procedural Knowledge on the Formation of Declarative Knowledge: How Accomplishing Activities Designed for Developing Learning Skills Impacts Teachers' Knowledge of Learning Skills. *Education Sciences*, 11(10), 598. <https://doi.org/10.3390/educsci11100598>
- Sam, R. (2024). Systematic Review of Inquiry-Based Learning: Assessing Impact and Best Practices In Education. *Research*. <https://doi.org/10.12688/f1000research.155367.1>
- Samuel, G. (2023). Increasing Student Engagement in Remote Learning Using Self-Assessment. In *Innovative Approaches to Online Education*, 47-70. <https://doi.org/10.4018/978-1-6684-5503-6.ch003>
- Sandika, B., & Fitrihidajati, H. (2018). Improving Creative Thinking Skills and Scientific Attitude through Inquiry-Based Learning in Basic Biology Lecture Toward Students Of Biology Education. *JPBI*, 4(1), 23. <https://doi.org/10.22219/jpbi.v4i1.5326>
- Sarioglan, A. B. (2021). Development of Inquiry-Based Learning Environment Scale: A Validity and Reliability Study. *Malaysian Online Journal of Educational Sciences*, 9(4). Retrieved from <https://files.eric.ed.gov/fulltext/EJ1315800.pdf>
- Schacter, D. L., & Slotnick, S. D. (2021). The Cognitive Neuroscience of Memory: An Overview. *Journal of Cognitive Neuroscience*, 33(3), 400-410. https://doi.org/10.1162/jocn_a_01703
- Schmidt, S. (2024). Responsibility for Rationality: Foundations Of An Ethics Of Mind. <https://doi.org/10.4324/9781003382973>
- Seden, K., Thomas, D. A., & Rinchen, S. (2023). Effects of Self-Assessment on Students' Evaluative Skills: A Convergent Mixed-Methods Study at Samtse College of Education. *Assessment Matters*. <https://doi.org/10.18296/am.0064>
- Sekaringtyas, T., Suryono, S., & Hadi, W. (2024). The Influence of Understanding Science Concepts, Critical Thinking Skills, and Scientific Literacy on Scientific Attitudes Class IV Primary School Students. *Journal of Ecohumanism*, 3(8). <https://doi.org/10.62754/joe.v3i8.5228>
- Senisum, M., & Edu, A. L. (2023). Enhancing Observation and Questioning Skills in Rural Science Education. *Jurnal Penelitian Pendidikan IPA*, 9(12), 11855–11861. <https://doi.org/10.29303/jppipa.v9i12.5796>
- Shanderi, I., & Suwardi, S. (2023). Scientific Attitudes in Chemistry Learning: A Systematic Literature Review. *Jurnal Pendidikan Kimia*, 15(2). DOI 10.24114/jpkim.v15i2.48881.
- Shenton, A. K. (2024). Training School Students in Information Evaluation. *Journal of Information Literacy*, 18(1). <https://doi.org/10.11645/18.149>
- Shintawati, A., Atmojo, I. R. W., & Ardiansyah, R. (2023). The Influence of Metacognitive Awareness on the Critical Thinking Ability of PGSD UNS Surakarta Students. *Jurnal Pendidikan dan Pengajaran*, 11(3). <https://doi.org/10.20961/ddi.v11i3.76819>
- Shofiah, N., Putera, Z. F., & Widiastuti, S. (2024). Collaborative Writing Learning in Inquiry to Improve Critical Thinking Skills. *Journal of English for Academic and Specific Purposes*, 7(1). <https://doi.org/10.18860/jeasp.v7i1.26429>
- Sidelil, A., & Feza, N. (2019). Assessment of Students' Conceptual Knowledge in Limit of Functions. *Journal on Mathematics Education*, 15(2), 12. <https://doi.org/10.29333/IEJME/6294>
- Siedlecki, S. L. (2020). Understanding Descriptive Research Designs and Methods. *Clinical Nurse Specialist*, 34(1), 8-12. <https://doi.org/10.1097/NUR.0000000000000493>
- Simbolon, M. E., Ramli, M., & Handayani, S. (2021). How Scientific Attitude Like Scientists Have? A Content Analysis of The Narrative Book that Represents Stephen Hawking's Journey Of Life. <https://doi.org/10.4108/EAI.12-12-2020.2305016>
- Şimşek, P., & Kabapınar, F. (2010). The Effects of Inquiry-Based Learning on Elementary Students' Conceptual Understanding of Matter, Scientific Process Skills, And Science Attitudes. *Procedia - Social and Behavioral Sciences*, 2(2), 1701–1705. <https://doi.org/10.1016/j.sbspro.2010.03.170>
- Siswi, N. R. T., Hidayat, T., & Wulandari, R. (2023). Innovation for Measuring Students' Metacognitive Abilities through Project-Based Learning. *Jurnal Inovasi dan Teknologi Pembelajaran*, 10(1), 71-71. <https://doi.org/10.17977/um031v10i12023p071>
- Smith, J. A., & Johnson, L. M. (2020). Problem-Focused Coping and Academic Stress: A Systematic Review. *Journal of Educational Psychology*, 112(4), 789-805. <https://doi.org/10.1037/edu0000398>
- Snow, N. (2022). The Value of Open-Mindedness and Intellectual Humility for Interdisciplinary Research. *Scientia et Fides*, 10(2), 51-67. <https://doi.org/10.12775/setf.2022.018>
- Smith, A. J. H. (2024). Ethical Considerations in Practitioner Research. *Advances in Higher Education and Professional Development Book Series*, 29–56. <https://doi.org/10.4018/979-8-3693-1499-9.ch002>
- Southworth, J. (2021). A Perspective-Taking Theory of Open-Mindedness: Confronting the Challenge of Motivated Reasoning. *Educational Theory*, 71(6), 715-730. <https://doi.org/10.1111/edth.12497>



- Stambouli, O. A., Pegka, S. S., Gerathanassis, I. P., & Tsaparlis, G. (2023). Undergraduate Chemistry Students' Perceived Abilities and Declarative Knowledge on Some Basic Aspects and Concepts of Spectroscopy. *Journal of Chemical Education*, 100(36). <https://doi.org/10.1021/acs.jchemed.2c00720>
- Stanton, J. D., Sebesta, A. J., & Dunlosky, J. (2021). Fostering Metacognition to Support Student Learning and Performance. *CBE—Life Sciences Education*, 20(1), <https://doi.org/10.1187/cbe.20-12-0289>
- Stofer, K. A., Hanson, D., & Hecht, K. (2022). Scientists Need Professional Development to Practice Meaningful Public Engagement. *Journal of Science Communication*, 21(4), Article 2127672. <https://doi.org/10.1080/23299460.2022.2127672>
- Suastra, I. W., & Ristiati, N. P. (2019). Developing Critical Thinking, Scientific Attitude, and Self-Efficacy in Students through Project-Based Learning and Authentic Assessment in Science Teaching at Junior High School. *Journal of Physics: Conference Series*, 1233, 012087. <https://doi.org/10.1088/1742-6596/1233/1/012087>
- Suharto, S., Widada, W., Susanta, A., & Haji, S. (2020). The Ability to Understand Concepts: Cognitive Style, Cognitive Structure, Learning Styles and Learning Motivation. *Jurnal Pendidikan IPA Indonesia*, 5(1), 15-22. <https://doi.org/10.33369/PENDIPA.5.1.15-22>
- Sulistyaningrum, I. S., Hartanto, R., & Permanasari, A. E. (2020). Students' Self-Monitoring Skill Classification in Learning Activities. *Proceedings of the 4th International Conference on Learning Innovation and Quality Education*, 66-69. <https://doi.org/10.2991/ASSEHR.K.200521.014>
- Sun, D., & Li, Y. (2019). Effectiveness Of Digital Note-Taking on Students' Performance in Declarative, Procedural and Conditional Knowledge Learning. *International Journal of Emerging Technologies in Learning*, 14(18), 108-119. <https://doi.org/10.3991/IJET.V14I18.10825>
- Sun, Z. (2021). Psychological Concept of The Scientific Rationality Types: Development of Scientific Knowledge. *Voprosy Filosofii*, 34-44. <https://doi.org/10.21146/0042-8744-2022-11-34-44>
- Sutirna, S., & Safuri, M. (2023). The Importance of Understanding Ability, Skills and Attitudes of Students in the Practice of Guidance and Counseling Services. *Bulletin of Counseling and Psychotherapy*. <https://doi.org/10.51214/00202305611000>
- Suyatman, S., Saputro, S., Sunarno, W., & Sukarmin, S. (2021). Profile Of Student Analytical Thinking Skills In The Natural Sciences By Implementing Problem-Based Learning Model. *Journal of Educational, Cultural and Psychological Studies*, 89-111. <https://doi.org/10.7358/ECPS-2021-023-SUYA>
- Syarifuddin, S. (2023). The Effect of Inquiry-Based Learning on Students' Mastery of Concept and Social Skills. *JTAM (Jurnal Teori dan Aplikasi Matematika)*, 7(2), 434-434. <https://doi.org/10.31764/jtam.v7i2.13236>
- Tak, C. C., Zulnaidi, H., & Eu, L. K. (2022). Measurement Model Testing: Adaption of Metacognitive Awareness toward Mathematic Reasoning among Undergraduate Education Students. *Contemporary Mathematics and Science Education*, 3(2), ep22021. <https://doi.org/10.30935/conmaths/12510>
- Talampas, M. (2023). Into The Lens of Inquiry-Based Learning (IBL): Student's Engagement, Motivation, and Attitudes among Grade 10 Students Of An Integrated High School. <https://doi.org/10.69651/pjihss030323>
- Taramopoulos, A., & Psillos, D. (2022). Developing Procedural Knowledge in Secondary Education Students. *Journal of Physics: Conference Series*, 2297(1), 012010. <https://doi.org/10.1088/1742-6596/2297/1/012010>
- Telaumbanua, Y. N., Syahputra, E., & Surya, E. (2024). Students' Metacognitive Awareness in Mathematics Learning. *Academy of Education Journal: Jurnal Ilmu-ilmu Kependidikan*. <https://doi.org/10.47200/aoej.v15i1.2359>
- Tarwiyani, T., & Mahanal, S. (2020). The Influence of Science Learning Based on Inquiry Integrated with Nature of Science (NOS) towards Students' Attitudes and Interests in Science. 2215, 030020. <https://doi.org/10.1063/5.0000633>
- Tjabolo, S. A., Maliki, P. L., & Lasido Irfani, I. (2022). Metacognitive Awareness of Madrasah Tsanawiyah Students in Gorontalo City in the Implementation of Online Learning. *E-journal*, 18(2), 149-164. <https://doi.org/10.30603/ir.v18i2.3068>
- Toleva-Stoimenova, S., & Rasheva-Yordanova, K. (2023). Developing Analytical Thinking Skills in Higher Education. *Obrazovanie i Tehnologii*, 14(1), 86-90. <https://doi.org/10.26883/2010.231.4977>
- Tommasi, M., Petricca, P., Cozzolino, G., & Casadio, C. (2021). Attitudes towards Scientific Knowledge: Social Dispositions and Personality Traits. *Synthese*, 199(1), 1-21. <https://doi.org/10.1007/S11229-020-02632-0>
- Tomory, I. (2023). Student Centered Methods, Soft Skills and Competency Based Learning from the View Of Engineering and Technical Teacher Students. *Proceedings of CELDA 2023*. https://doi.org/10.33965/celda2023_2023061015
- Trincherro, R. (2020). The Role of Self-assessment of Learning in University Education: Ideas from field research. *Formazione: Open Journal for Online Education*, 20(1), 93-114. <https://doi.org/10.13128/FORM-8245>

- United Nations Educational, Scientific and Cultural Organization. (2020). Measuring Global Education Goals: How TIMSS Helps – Monitoring Progress towards Sustainable Development Goal 4 Using Trends in International Mathematics and Science Study. International Association for the Evaluation of Educational Achievement. Retrieved from https://www.iea.nl/sites/default/files/2020-12/EN_IEA%20UNESCO%20Joint-report_TIMSS%202019-final.pdf
- Urdanivia Alarcon, D. A., Talavera-Mendoza, F., Rucano Paucar, F. H., Cayani Caceres, K. S., & Machaca Viza, R. (2023). Science and Inquiry-Based Teaching and Learning: A Systematic Review. *Frontiers in Education*, 8, 1170487. <https://doi.org/10.3389/educ.2023.1170487>
- Uwayezu, D., Ntigura, E., Gatarayiha, A., Erem, A. S., Haque, M., Majumder, M. A. A., & Razzaque, M. S. (2022). Conflict between Science and Superstition in Medical Practices. *International Medical Education*, 1(2), 33–42. <https://doi.org/10.3390/ime1020007>
- Valenzuela, S., & Bachmann, I. (2017). Path Analysis. In the International Encyclopedia of Communication Research Methods, 1-10. <https://doi.org/10.1002/9781118901731.iecrm0181>
- Van der Waltd, G. (2020). Constructing Conceptual Frameworks in Social Science Research. *The Journal for Transdisciplinary Research in Southern Africa*, 16(1), 758. <https://doi.org/10.4102/td.v16i1.758>
- Van der Zalm, A. J., Barroso, J., Browne, P., Casey, W., Gordon, J., Henry, T. R., Kleinstreuer, N. C., Lowit, A. B., Perron, M., & Clippinger, A. J. (2022). A Framework for Establishing Scientific Confidence in New Approach Methodologies. *Archives of Toxicology*, 96, 2865-2880. <https://doi.org/10.1007/s00204-022-03365-4>
- Van Deursen, A. J. A. M. (2020). Digital Inequality During a Pandemic: Quantitative Study of Differences in COVID-19-Related Internet Uses and Outcomes among the General Population. *JMIR Publications*, 22(8). <https://doi.org/10.2196/20073>
- Velmurugan, P. (2019). A Study on Scientific Attitude of Elementary Teacher Education Students. *Psychology and Behavioral Science International Journal*, 11(1). <https://doi.org/10.19080/PBSIJ.2019.11.555805>
- Vendrell-Morancho, M., Rodríguez-Mantilla, J. M., & Fernández-Díaz, M. J. (2024). (2024). Predictors of Critical Thinking in Spanish University Students. *Revista Iberoamericana sobre Calidad, Eficacia y Cambio en Educación*, 22(3), 23-45. <https://doi.org/10.15366/reice2024.22.3.002>
- Verawati, N. N. S. P., Harjono, A., & Prayogi, S. (2024). Analysis of Students' Critical Thinking Disposition in Science Learning. *JPFT (Jurnal Pendidikan Fisika dan Teknologi)*, 10(1), 200-210. <https://doi.org/10.29303/jpft.v10i1.7127>
- Vygotsky, L. (1978). *Mind in Society*. London: Harvard University Press. Retrieved from <https://home.fau.edu/musgrove/web/vygotsky1978.pdf>
- Wale, B., & Bishaw, K. S. (2020). Effects of Using Inquiry-Based Learning on EFL Students' Critical Thinking Skills. *Asian-Pacific Journal of Second and Foreign Language Education*, 5(1). <https://doi.org/10.1186/s40862-020-00090-2>
- Wang, H. S., Chen, S., & Yen, M. H. (2021). Effects of Metacognitive Scaffolding on Students' Performance and Confidence Judgments in Simulation-Based Inquiry. *Physical Review Physics Education Research*, 17(2), 020108. <https://doi.org/10.1103/PHYSREVPHYSEDUCRES.17.020108>
- Wang, N. (2024). Exploring Big Ideas-Based Holistic Unit Teaching Design from the Perspective of Ausubel's Subsumption Theory. *Journal of Education and Educational Research*, 9(2), 306. <https://drpress.org/ojs/index.php/jeer/article/view/23308/22856>
- Wang, N., Xu, Q., Li, G., & Zhang, Y. (2020). Cultivate Students' Innovation Ability Based on the Follow-Up Study of Contest Problems. *International Conference on Big Data and Information Engineering*, 030064. <https://doi.org/10.1109/ICBDIE50010.2020.00052>
- Wanzer, D. L. (2020). What is Evaluation?: Perspectives of How Evaluation Differs from Research. *Communication Education*, 42(1). <https://doi.org/10.1177/1098214020920710>
- Wardani, M., Feronika, T., & Ardianti, D. L. (2024). Analysis of Students' Critical Thinking Skills in Conventional Learning. *Lavoisier*, 3(1), 15-22. <https://doi.org/10.24952/lavoisier.v3i1.11598>
- White, M. G. (2020). Why Human Subjects Research Protection is Important. *Ochsner Journal*, 20(1), 16–33. <https://doi.org/10.31486/toj.20.5012>
- Widinda, N. A. (2020). Analysis of Students' Understanding Ability in Scientific Writing Technique Course. *AIP Conference Proceedings*, 2229(1), 020013. <https://doi.org/10.1063/5.0002912>
- Winthrop, R., Ziegler, L., Handa, R., & Fakoya, F. (2019). How Playful Learning Can Help Leapfrog Progress in Education. Center for Universal Education at Brookings. Retrieved from https://www.brookings.edu/wpcontent/uploads/2019/04/how_playful_learning_can_help_leapfrog_progress_in_education.pdf
- Wirzal, M. D. H., Halim, N. S. A., Nordin, N. A. H. M., & Bustam, M. A. (2022). Metacognition in Science Learning: Bibliometric Analysis of Last Two Decades. *Jurnal Penelitian dan Pengkajian Ilmu Pendidikan: e-Saintika*, 6(1), 43–60.



<https://doi.org/10.36312/esaintika.v6i1.665>

Wong, Z. Y., & Liem, G. A. D. (2021). Student Engagement: Current State of the Construct, Conceptual Refinement, and Future Research Directions. *Educational Psychology Review*, 43(2), 123-145. <https://doi.org/10.1007/s10648-021-09628-3>

Woolley, J. D., Baca, P. A., & Kelley, K. A. (2023). Development of a Naïve Theory Of Superstition. *Journal of Cognition and Development*. <https://doi.org/10.1080/15248372.2023.2256871>

World Bank. (2022). Learning Poverty Report. Conference Edition,7. Retrieved from <https://thedocs.worldbank.org/en/doc/e52f55322528903b27f1b7e61238e416-0200022022/original/Learning-poverty-report-2022-06-21-final-V7-0-conferenceEdition.pdf>

Wulandari, H. Y. A., Ekawati, R., & Shodikin, A. (2024). Exploring Creative Thinking Skill. *Jupitek*, 7(1), 22-32. <https://doi.org/10.30598/jupitekvol7iss1pp22-32>

Wynn, G. (2024). Reformative Concept Analysis for Applied Psychology Qualitative Research. *Qualitative Research in Psychology*, 21(3), 251–278. <https://doi.org/10.1080/14780887.2024.2346851>

Wynn, G. (2024). Reformative Concept Analysis for Applied Psychology Qualitative Research. *Qualitative Research in Psychology*, 21(3), 251–278. <https://doi.org/10.1080/14780887.2024.2346851>

Xiong, X., & Noichun, D. (2022). Talking About How to Improve Learners' Self-Monitoring Ability with Practice. *Language Education*, 10(5), 159-159. <https://doi.org/10.18282/l-e.v10i5.2717>

Yamine, E., & Rammal, A. (2021). Path Analysis o Assess Socio-Economic and Mitigation Measure Determinants for Daily Coronavirus Infections. *International Journal of Environmental Research and Public Health*, 18(19), 10071. <https://doi.org/10.3390/ijerph181910071>

Yau, S. A., Majid, F. A., Sharil, W. N. E. H., Halim, N. D. A., Zaid, N. M., & Mokhtar, M. (2023). The Perceived Impact of Critical Thinking on Student's Learning Performance. *International Journal of Academic Research in Business and Social Sciences*, 13(6), 974 – 991. <http://dx.doi.org/10.6007/IJARBS/v13-i6/17220>

Yeoh, C. P., Li, C. T., & Hou, H. T. (2024). Game-Based Collaborative Scientific Inquiry Learning Using Realistic Context and Inquiry Process-Based Multidimensional Scaffolding. *International Journal of Science Education*. <https://doi.org/10.1080/09500693.2024.2354944>

Yu, S., Jantharajit, N., & Srikhao, S. (2024). Collaborative Inquiry-Based Instructional Model to Enhance Mathematical Analytical Thinking and Reasoning Skills for Fourth-Grade Students. *Asian Journal of Education and Training*. <https://doi.org/10.20448/edu.v10i1.5323>

Zaidi, F. Z., & Zaidi, A. R. Z. (2022). Strategies for Improving Memory in Students. *Journal of Student Health and Medical Development*, 3(2), 197-200. <https://doi.org/10.53685/jshmdc.v3i2.130>

Zulnaidi, H., Tak, C. C., & Eu, L. K. (2022). Measurement Model Testing: Adaption of Self-Efficacy and Metacognitive Awareness among University Students. *Eurasia Journal of Mathematics, Science and Technology Education*, 18(9), em2153-em2153. <https://doi.org/10.29333/ejmste/12366>.

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